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Washington, D. C.

December 1974

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Volume 15, Number 10, October 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

Environmental Monitoring and Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1973[1]

M. E. Miles, G. L. Sjoblom, and J. D. Eagles[2]

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity, less tritium discharged to all ports and harbors from the more than 100 Naval nuclear-powered ships and supporting tenders, Naval bases and shipyards was less than 0.002 curie in 1973. The total tritium released to all ports and harbors was less than 1 curie in 1973. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of 103 U.S. Naval nuclear-powered submarines and 4 nuclear-powered surface ships in operation. Support facilities involved in construction, maintenance, overhaul and refueling of these nuclear propulsion plants include 9 shipyards, 11 tenders, and 2 submarine bases. This report describes disposal of radioactive liquid wastes, disposal of solid wastes and monitoring of the environment to determine the effect of radioactive releases. This report concludes that radioactivity associated with U.S. Naval nuclear-powered ships has had no significant or discernible effect on the quality of the environment. A summary of the radiological environmental information supporting this conclusion follows.

From the start of the Naval nuclear propulsion program, the policy of the U.S. Navy has been to reduce to the minimum practicable, the amounts of radioactivity released into harbors. Navy procedures to accomplish this have been reviewed with the U.S. Atomic Energy Commission (AEC) and the U.S. Environmental Protection Agency (EPA). The total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities in recent years is shown in table 1.

Table 1. Total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities, 1969–1973

Year	Number of ships in operation	Volume (1 000 gallons)	Radioactivity less tritium (curies)
1969	91	3 326	0.048
1970	96	2 571	.024
1971	100	1 089	<.002
1972	104	289	<.002
1973	107	<25	<.002

As a measure of the significance of these data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in 1973, he would not exceed the annual radiation exposure permitted by the U.S. Atomic Energy Commission for its employees and licensees.

Although of less significance than the amount of radioactivity released, table 1 shows the volume of liquids released within 12 miles has been reduced from millions of gallons per year to less than 25 thousand gallons in 1973. This reduction was achieved by reduction of waste generation and by processing and reuse of wastewater.

---

[1] Previously released as Report NT–74–1 (April 1974).

[2] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

Environmental monitoring is conducted by the U.S. Navy in United States and foreign harbors frequented by U.S. naval nuclear-powered ships. This monitoring consists of analyzing harbor water and sediment samples for radioactivity associated with naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities and effluent monitoring. Environmental samples from each of these harbors are also checked at least annually by an AEC laboratory to ensure that analytical procedures are correct and standardized. The EPA has conducted independent surveys in United States harbors; results have been consistent with Navy results. These surveys have confirmed that U.S. naval nuclear-powered ships and support facilities have had no significant effect on the radioactivity of the marine environment.

Radioactive liquid waste disposal

Policy and procedures minimizing release of radioactivity in harbors

The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment but particularly within 12 miles from shore including into harbors. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated in EPA in 1970), U.S. Atomic Energy Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences—National Research Council (*1–7*). Keeping releases small minimizes the radioactivity available to build up in the environment or to concentrate in marine life. To implement this policy of minimizing releases, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed and concurred in by the AEC and the U.S. Public Health Service. (The radiological surveillance organization of U.S. Public Health Service has since been moved to the U.S. Environmental Protection Agency.)

Source of radioactivity

In the shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor coolant water expands as a result of being heated to operating temperature; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives greater than 1 day in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, zirconium-95, tantalum-182, manganese-54, cobalt-58, and cobalt-60. The predominant and also longest-lived of these is cobalt-60, which has a 5.3 year half-life; cobalt-60 also has the most restrictive concentration limit in water listed by organizations which set radiological standards (*1–3*) for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is conservatively controlled by assuming that all the long-lived radioactivity is cobalt-60.

Support facilities are equipped with processing systems to remove most of the radioactivity from liquid waste prior to release into harbors. These liquid wastes result from transferring water from ships as well as decontaminating radioactivity contaminated piping systems and laundering anticontamination clothing worn by personnel.

Liquid waste releases in harbors

The total amounts of long-lived radioactiv-

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Table 2. Radioactive liquid waste released to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1969 through 1973 [a]

Facility	1969		1970		1971		1972		1973	
	Volume (1 000 gallons)	Radio-activity (curies)	Volume (1 000 gallons)	Radio-activity (curies)	Volume (1 000 gallons)	Radio-activity (curies)	Volume (1 000 gallons)	Radio-activity (curies)	Volume (1 000 gallons)	Radio-activity (curies)
Portsmouth, N.H.; Naval Shipyard	87	0.002	68	0.002	51	<0.001	25	<0.001	<1	<0.001
Groton-New London, Conn; Electric Boat Division, Tender at State Pier and Sub Base	615	.006	359	.004	258	<.001	151	<.001	<1	<.001
Newport News, Va; Newport News Shipbuilding	870	.022	1 466	.013	262	<.001	13	<.001	16	<.001
Norfolk, Va; Naval Shipyard and Tender	102	.005	98	.001	38	<.001	18	<.001	<1	<.001
Charleston, S.C.; Naval Shipyard and Tenders	131	.001	58	<.001	45	<.001	8	<.001	1	<.001
Pascagoula, Miss; Ingalls Nuclear Division	8	<.001	7	<.001	28	<.001	12	<.001	<1	<.001
San Diego, Calif; Tenders at Ballast Point	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Long Beach, Calif; Naval Shipyard and Base	2	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Vallejo, Calif; Mare Island Naval Shipyard	80	.001	121	.002	219	<.001	7	<.001	3	<.001
Bremerton, Wash; Puget Sound Naval Shipyard	152	.001	136	<.001	98	<.001	16	<.001	<1	<.001
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	1 279	.008	258	.002	90	<.001	38	<.001	2	<.001
Apra Harbor, Guam	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
All other harbors, United States and foreign	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Total	3 326	0.048	2 571	0.024	1 089	<0.002	289	<0.002	<25	<0.002

[a] Radioactivity data has been standardized to cobalt-60 and excludes tritium. Volumes are prior to dilution. A total of 0.02 curie was discharged into the river at Quincy, Mass. from 1961 through March 1969 when all work on U.S. Naval nuclear-powered ships was discontinued at General Dynamics, Quincy Division. Slight differences in volumes and radioactivity data from past reports result from using more significant figures in this table. Volumes less than 500 gallons are shown as <1 thousand. Curies less than 0.0005 are shown as <0.001.

ity released into harbors and seas within 12 miles from shore during the past 5 years are summarized in table 2, which updates information in references *8* through *15*. Included are data on releases from U.S. nuclear-powered ships and from supporting shipyards, tenders and submarine bases. Locations listed in table 2 include all operating bases and home ports in the United States and overseas as well as all other ports which were visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this table are conservatively reported as if the entire radioactivity consisted of cobalt-60, which is the predominant long-lived radionuclide and also has the most stringent concentration limits.

Although of less significance than the amount of radioactivity, the volume of waste has also been reduced. The average volume released into all harbors in the middle 1960's was 5 million gallons per year. In 1973, the volume released was less than 25 000 gallons. This reduction was achieved by reduction of waste generation and by processing and reuse of waste water.

The table shows that the total amount of radioactivity released within all United States and foreign harbors by the more than 100 nuclear-powered ships in the U.S. Navy has been less than 0.002 curie per year since 1970. To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity (*16*) in the volume of saline harbor water occupied by a single nuclear-powered submarine.

Short-lived radionuclides

Reactor coolant also contains short-lived radionuclides with half-lives of seconds to hours. Their highest concentrations in reactor coolant are from nitrogen-16 (7 second half-life), nitrogen-13 (10 minute half-life), fluorine-18 (1.8 hour half-life), argon-41 (1.8 hour half-life), and manganese-56 (2.6 hour half-life). During 1973, the total quantity of these short-lived radionuclides was less than 0.001 curie in any release from any ship. For the longest-lived of these, about 1 day after discharge from an operating reactor, the concen-

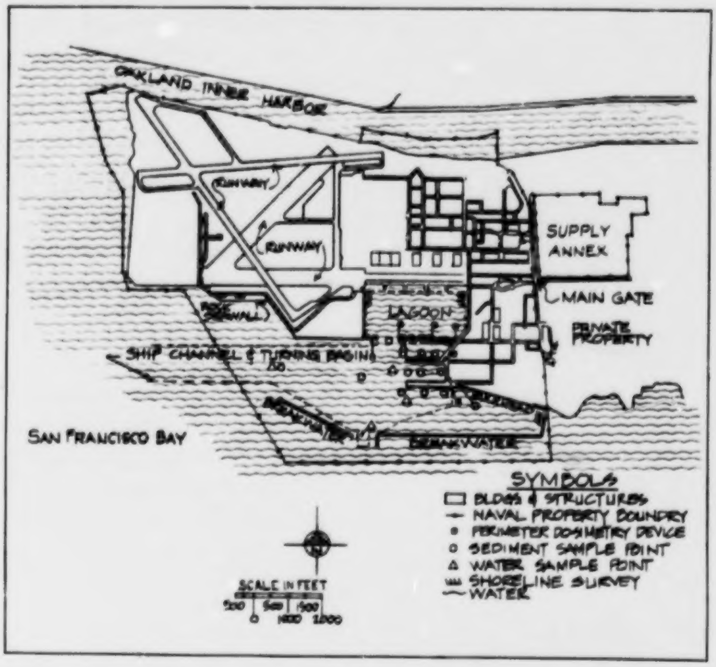
OAKLAND INNER HARBOR
RUNWAY
RUNWAY
SUPPLY ANNEX
MAIN GATE
PRIVATE PROPERTY
LAGOON
ROCK SEAWALL
SHIP CHANNEL & TURNING BASIN
SAN FRANCISCO BAY
BREAKWATER
SYMBOLS
BLDGS & STRUCTURES
NAVAL PROPERTY BOUNDRY
PERIMETER DOSIMETRY DEVICE
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
SHORELINE SURVEY
WATER
SCALE IN FEET
200 500 900
0 1000 2000

Figure 1. Environmental monitoring locations at the U.S. Naval Air Station, Alameda, Calif.

tration is reduced to one thousandth of the initial concentration and in about 2 days, the concentration is reduced to one millionth.

Most liquid releases from ships during new construction occur during heating up, prior to extensive power operation of the reactor and before any buildup of long-lived radionuclides in reactor coolant can occur. The total short-lived radioactivity of such releases in 1973 was less than 0.001 curie in 16 thousand gallons of water; these releases are included in table 2.

Fission product radionuclides

Fission products produced in the reactor are retained within the fuel elements. The fission gases, krypton and xenon, are also retained within the fuel elements. However, trace quantities of naturally occurring uranium impurities in reactor structural materials release small amounts of fission products to reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides, strontium-90 and cesium-137, in releases from U.S. Naval nuclear-powered ships and their support facilities has been less than 0.001 curie per year for all harbors combined. Fallout of these same fission products has often been more than this in one rainfall in a single harbor.

Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and other nuclear reactions. Although tritium has a 12-year half-life, the radiation produced is of such low energy that its radioactivity concentration guide issued by the International Commission on Radiological Protection, the AEC and by other standard-setting organizations is 100 times higher than the concentration guide for cobalt-60. This tritium is in the oxide form and chemically indistinguish-

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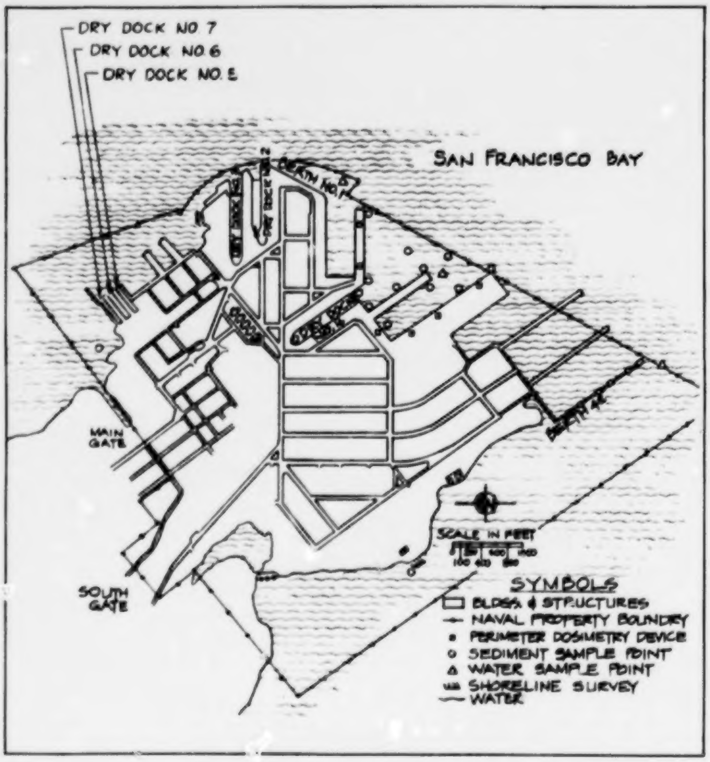
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SAN FRANCISCO BAY
BERTH NO. 1
MAIN GATE
SOUTH GATE
SCALE IN FEET
100 400 800
SYMBOLS
BLDGS. & STRUCTURES
NAVAL PROPERTY BOUNDRY
PERIMETER DOSIMETRY DEVICE
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
SHORELINE SURVEY
WATER

Figure 2. Environmental monitoring locations at the Hunters Point Naval Shipyard, San Francisco, Calif.

able from water; therefore it does not concentrate significantly in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference *17* reports that the production rate from this source is about 6 million curies per year, which through rainfall causes a tritium inventory in the oceans of about 100 million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released during each of the last 5 years from all U.S. Naval nuclear-powered ships and their supporting tenders, bases, and shipyards has been less than 200 curies. Most of this has been into the ocean more than 12 miles from shore. This total tritium from the entire nuclear Navy is less than typical electrical generating nuclear power stations release each year (*18,19*). Total tritium released into harbors within 12 miles was less than 1 curie in 1973. Such releases are too small to increase measurably the tritium concentration in the environment. Therefore, tritium has not been included in the data in other sections of this report.

Liquid waste releases at sea

Radioactive liquid wastes are released at sea under strict controls. These ocean releases are consistent with recommendations the Council on Environmental Quality made in 1970 to the President in reference *20*. Procedures and limits for ocean disposal have been consistent with recommendations made by the National Academy of Sciences—National Research Council in reference *5* and by the International Atomic Energy Agency in reference *6*. These releases have contained much less radioactivity than these reports considered would be acceptable. Total long-lived radioactivity excluding tritium, released farther than 12 miles from shore by U.S. Naval nuclear-powered ships and supporting tenders, is shown in table 3 for recent years. This is the total amount released from over 100 ships at different times of the year in the open sea at long distances from land in small incremental amounts, and under rapid dispersal conditions due to wave action. The quantity of radioactivity released to the open ocean in 1973 was 0.4 curie, which is less than

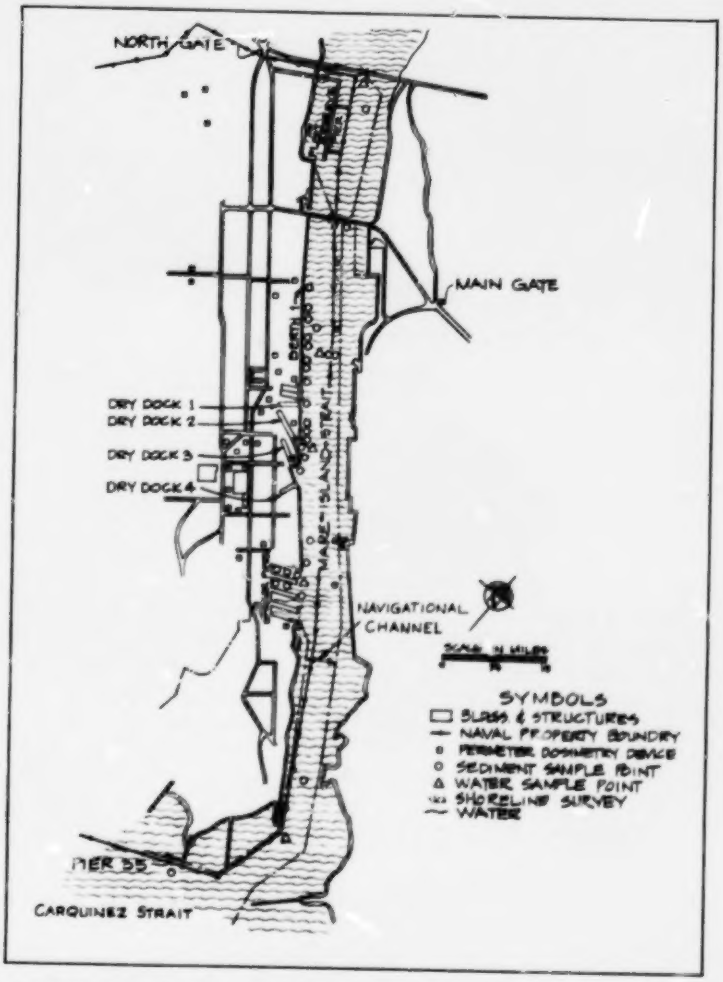
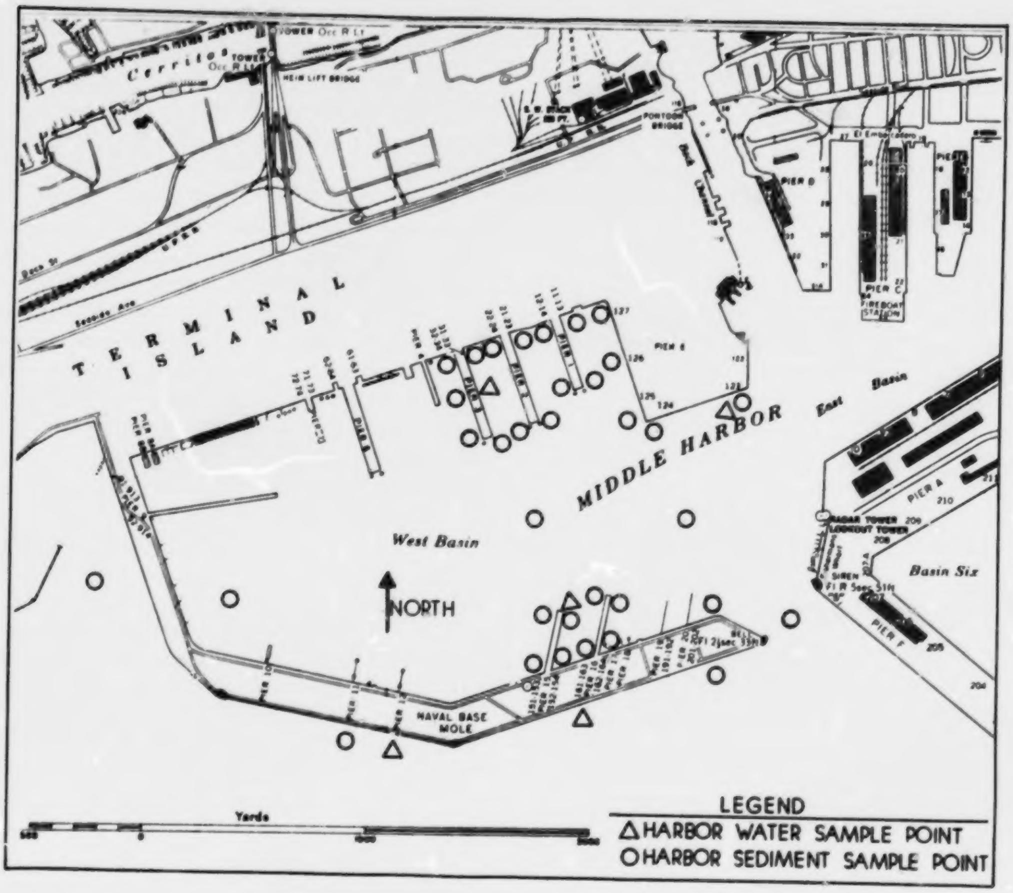

NORTH GATE
MAIN GATE
BERTH 1
MARE ISLAND STRAIT
DRY DOCK 1
DRY DOCK 2
DRY DOCK 3
DRY DOCK 4
NAVIGATIONAL CHANNEL
SCALE IN MILES
SYMBOLS
BLDGS & STRUCTURES
NAVAL PROPERTY BOUNDRY
PERIMETER DOSIMETRY DEVICE
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
SHORELINE SURVEY
WATER
PIER 35
CARQUINEZ STRAIT

Figure 3. Environmental monitoring locations at the Mare Island Naval Shipyard, Vallejo, Calif.


Cerritos
TOWER Occ R Lt
HEIM LIFT BRIDGE
PONTOON BRIDGE
PIER D
PIER C
FIREBOAT STATION
TERMINAL ISLAND
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MIDDLE HARBOR
East Basin
PIER A
RADAR TOWER
LOOKOUT TOWER
Basin Six
West Basin
NORTH
SIREN
PIER F
NAVAL BASE MOLE
Yards
LEGEND
△HARBOR WATER SAMPLE POINT
○HARBOR SEDIMENT SAMPLE POINT

Figure 4. Environmental monitoring survey chart, Long Beach harbor, Calif.

the naturally occurring radioactivity in a cube of sea water approximately 100 yards on a side.

Solid radioactive waste disposal

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap

Table 3. Total radioactive liquid waste released at sea by all U.S. Naval nuclear-powered ships and supporting tenders

Year	Volume (1 000 gallons)	Radio-activity less tritium (curies)
1969	1 570	1.7
1970	1 220	.8
1971	1 840	.8
1972	1 970	.6
1973	1 480	.4

Table 4. Radioactive solid waste from U.S. Naval nuclear-powered ships and their support facilities for 1969 through 1973 [a]

Facility	1969		1970		1971		1972		1973	
	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)	Volume (1 000 cubic feet)	Radio-activity (curies)
Portsmouth, N.H.; Naval Shipyard	8	3	14	16	12	9	9	4	7	3
Groton, New London, Conn; Electric Boat Division, Tender at State Pier and Sub Base	8	328	12	140	18	13	7	6	12	2
Newport News, Va; Newport News Shipbuilding	17	382	28	312	21	165	10	8	6	5
Norfolk, Va; Naval Shipyard and Tender	6	8	9	146	10	33	10	1 026	4	2
Charleston, S.C.; Naval Shipyard and Tenders	15	9	8	6	6	4	7	34	6	19
Pascagoula, Miss; Ingalls Nuclear Division	1	<1	0	0	2	<1	2	2	1	4
San Diego, Calif; Tenders at Ballast Point	<1	2	<1	1	2	<1	<1	<1	<1	<1
Long Beach, Calif; Naval Shipyard and Base	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Vallejo, Calif; Mare Island Shipyard	8	5	12	2	22	25	9	13	6	23
Bremerton, Wash; Puget Sound Naval Shipyard	11	42	18	1 327	21	59	9	22	10	21
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	4	3	5	4	4	2	4	147	7	143
Total	78	783	106	1 954	119	311	67	1 262	59	222

[a] This table includes all radioactive solid waste from tenders and nuclear-powered ships. This radioactivity is primarily cobalt-60. This radioactive waste is shipped to burial facilities licensed by the USAEC or State. Slight differences from past reports result from using different number of significant figures in this table. Volumes less than 500 cubic feet are reported as <1 thousand and less than 0.5 curie is reported as <1 curie.

materials are collected by nuclear-powered ships and their support facilities. Expended naval reactor fuel is transferred to the U.S. Atomic Energy Commission for reprocessing in the same manner as other expended nuclear fuel.

Solid radioactive materials from Naval nuclear-powered ships are not dumped at sea since the Navy procedures prohibit sea disposal of solid radioactive materials. Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary and shipped to burial sites licensed by the AEC or a State under agreement with AEC. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The Navy procedures require all packaging and shipping of radioactive materials to be performed in strict compliance with U.S. Department of Transportation and AEC requirements.

Table 4 summarizes total radioactivity and volumes of radioactive solid waste disposal for the last 5 years. Table 4 does not include wastes associated with expended fuel which is processed in special facilities by the AEC.

Because of efforts to minimize solid waste and the utilization of compaction equipment, total volumes have remained nearly constant in spite of increasing work caused by increasing number of ships. The average annual volume for the entire Naval nuclear propulsion program could be contained in a cube measuring 15 yards on a side. The radioactivity does not require excessively long time care in the licensed burial ground since the principal radionuclides do not have half-lives longer than 5 years. In 100 years, such radioactivity will have decayed to 1 millionth the initial radioactivity. In less than 200 years, the total of all radioactivity conservatively asumed to be cobalt-60 in table 4 will have decayed to less than 1 millionth of a curie and would not be detectable in the burial grounds using sensitive monitoring instruments.

Environmental monitoring

To provide additional assurance that procedures used by the U.S. Navy to control radioactivity are adequate to protect the en-

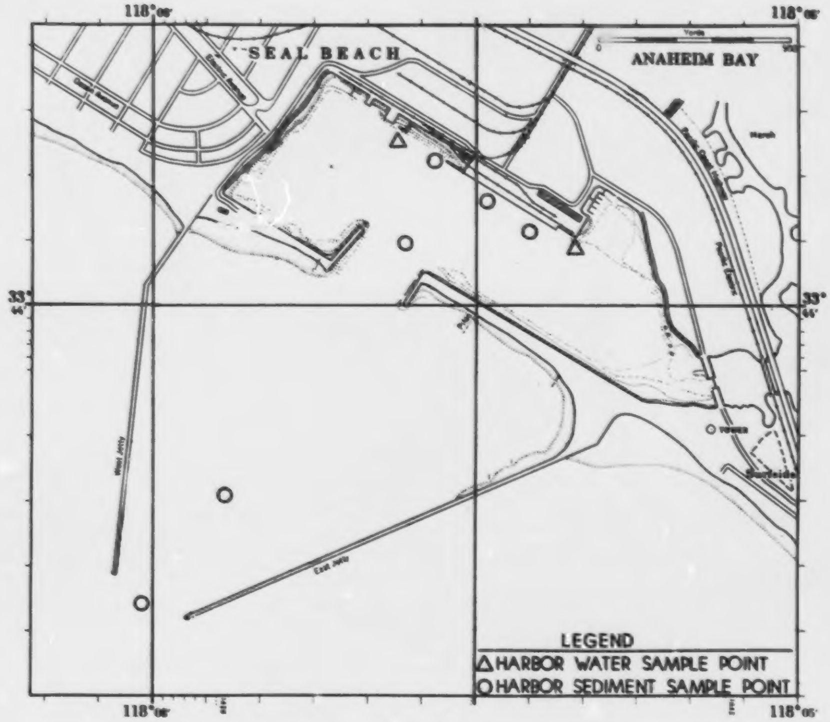

Figure 5. Environmental monitoring survey chart, Long Beach, California, Anaheim Bay area

vironment, the Navy conducts environmental monitoring in harbors frequented by its nuclear-powered ships. Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. To ensure thoroughness and objectivity, these surveys are made as independent as practicable from waste disposal operations. Samples from each harbor monitored are also checked at least annually by an AEC laboratory to ensure analytical procedures are correct and standardized. These AEC laboratory results have been consistent with shipyard and operating base results. As a further independent check of environmental monitoring, a laboratory of the Environmental Protection Agency has conducted detailed surveys of selected harbors (*21–24*). This laboratory has monitored the harbors at Charleston, S.C.; Pearl Harbor, Hawaii; San Diego, Calif.; Vallejo, Calif.; New London, Conn.; Newport News, Va.; and Norfolk, Va. Navy monitoring results have been consistent with these surveys.

The current Navy environmental monitoring program consists of analyzing samples of harbor water and sediment, supplemented by shoreline surveys, posted dosimeters, and effluent monitoring.

Five water samples are taken in each harbor once each quarter year in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross gamma radioactivity and for cobalt-60 content. Samples are analyzed using

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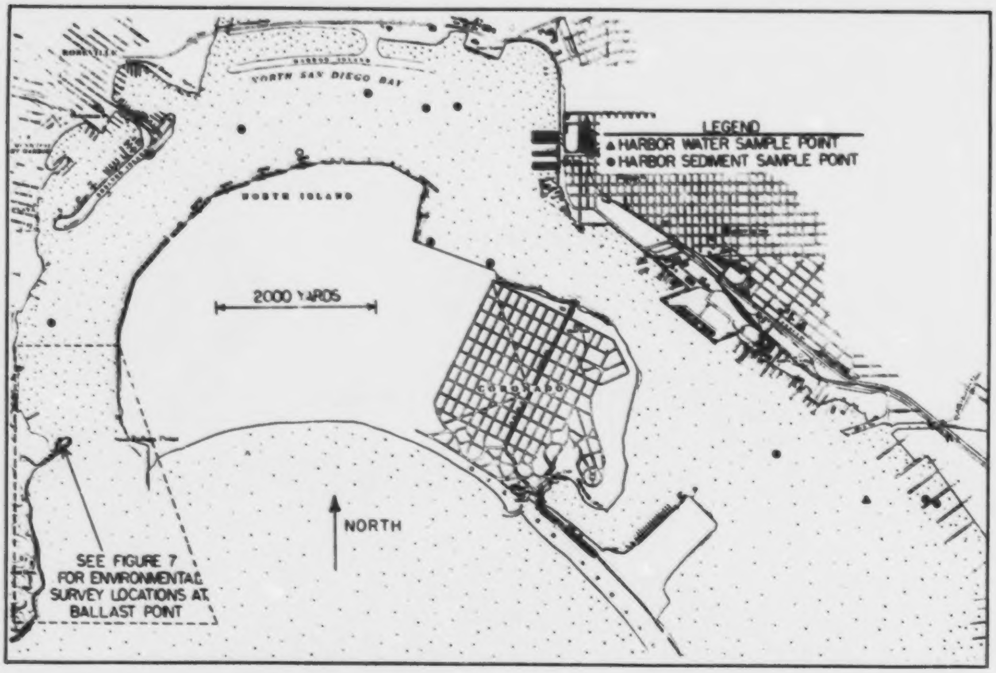
NORTH SAN DIEGO BAY
NORTH ISLAND
CORONADO
LEGEND
▲ HARBOR WATER SAMPLE POINT
● HARBOR SEDIMENT SAMPLE POINT
2000 YARDS
NORTH
SEE FIGURE 7 FOR ENVIRONMENTAL SURVEY LOCATIONS AT BALLAST POINT

Figure 6. Environmental monitoring survey chart, San Diego Bay, Calif.

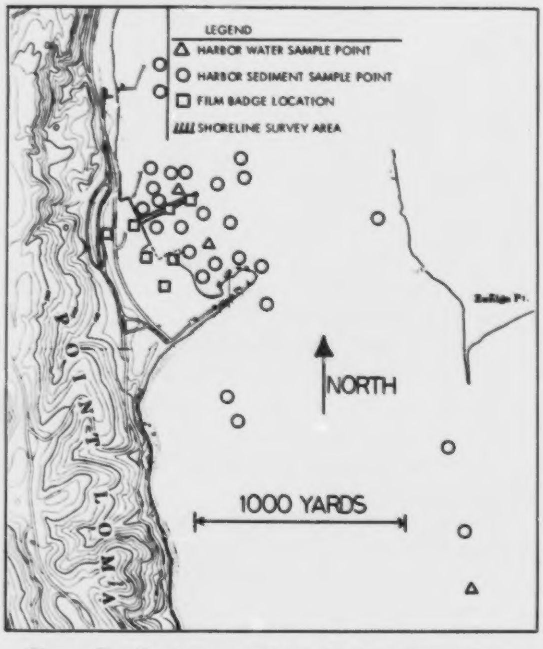
LEGEND
△ HARBOR WATER SAMPLE POINT
○ HARBOR SEDIMENT SAMPLE POINT
□ FILM BADGE LOCATION
SHORELINE SURVEY AREA
NORTH
1000 YARDS
POINT LOMA

Figure 7. Environmental monitoring survey chart, Ballast Point, San Diego harbor, Calif.

a sodium iodide scintillation detector with a multichannel analyzer. Procedures for analysis will detect cobalt-60 if its concentration exceeds one three hundredth of the AEC limit (*1*). No cobalt-60 has been detected in any of the water samples from all harbors monitored.

A radiological laboratory now part of the Environmental Protection Agency analyzed samples from harbors to identify radionuclides present in sediment. These analyses showed cobalt-60 was the predominant radionuclide added to sediment from Naval nuclear reactor operations. Therefore, Navy monitoring procedures require collecting in each harbor approximately 20 to 120 sediment samples once each quarter year. Standard 6-inch square samplers modified to collect only the top ½ to 1 inch of sediment are used. The top layer was selected because it should be more mobile and more accessible to marine life than deeper layers. The samples are analyzed for gross gamma radioactivity and for cobalt-60. Results of the 2967 sediment samples from harbors

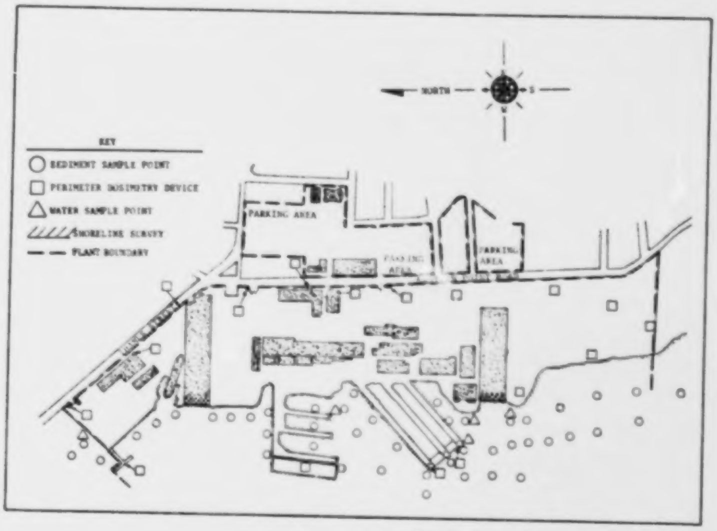
NORTH
S
N
KEY
○ SEDIMENT SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
△ WATER SAMPLE POINT
SHORELINE SURVEY
— — PLANT BOUNDARY
PARKING AREA
PARKING AREA
PARKING AREA

Figure 8. Environmental survey, General Dynamics/Electric Boat Groton, Conn.

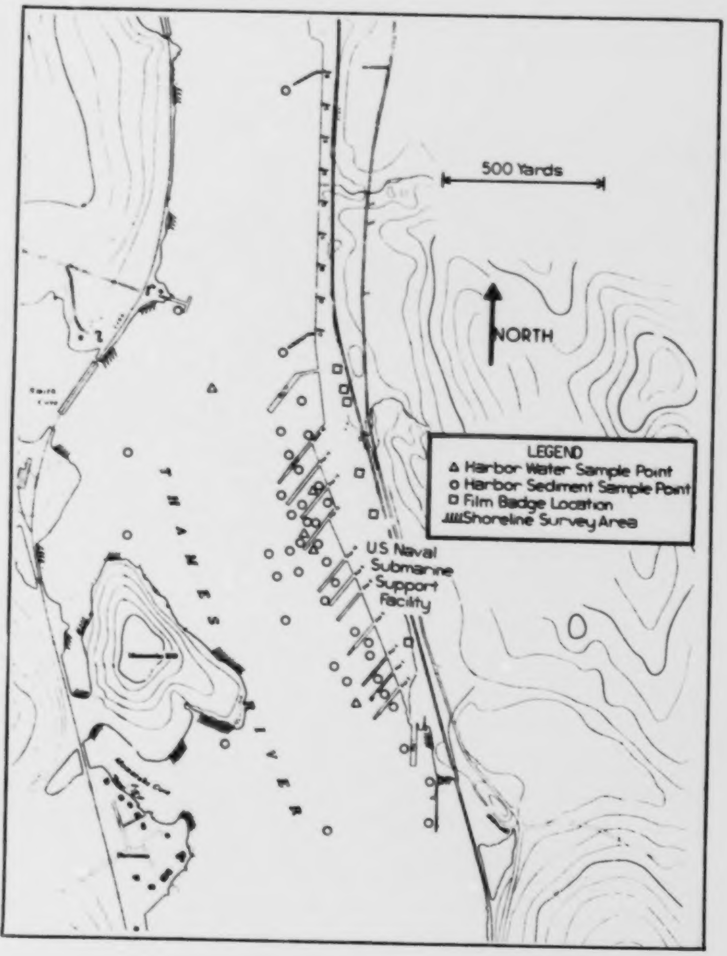
500 Yards
NORTH
LEGEND
△ Harbor Water Sample Point
○ Harbor Sediment Sample Point
□ Film Badge Location
Shoreline Survey Area
US Naval Submarine Support Facility
THAMES RIVER

Figure 9. Environmental monitoring survey, U.S. Naval Submarine Support Facility, New London harbor, Conn.

14

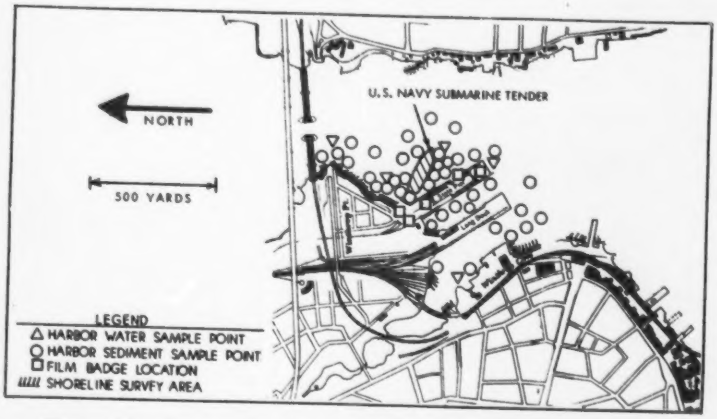
U.S. NAVY SUBMARINE TENDER
NORTH
500 YARDS
LEGEND
△ HARBOR WATER SAMPLE POINT
○ HARBOR SEDIMENT SAMPLE POINT
□ FILM BADGE LOCATION
//// SHORELINE SURVEY AREA

Figure 10. Environmental monitoring survey chart, State Pier, New London, Conn.

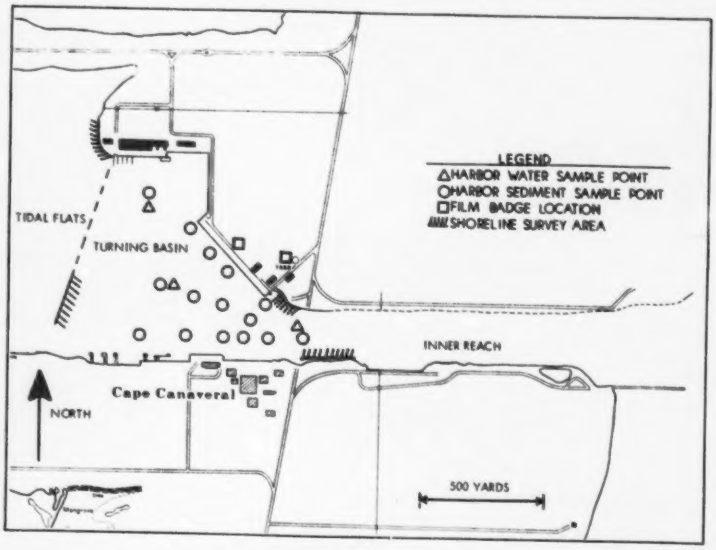
LEGEND
△HARBOR WATER SAMPLE POINT
○HARBOR SEDIMENT SAMPLE POINT
□FILM BADGE LOCATION
////SHORELINE SURVEY AREA
TIDAL FLATS
TURNING BASIN
INNER REACH
Cape Canaveral
NORTH
500 YARDS

Fig. 11. Environmental monitoring survey chart, Port Canaveral, Fla.

monitored by the Navy in the United States and possessions for 1973 are summarized in table 5.

Figures 1 through 26 show environmental monitoring survey charts of U.S. ports and harbors.

Evaluation of the data summarized in table 5 shows that low-level cobalt-60 radioactivity in harbor bottom sediment is detected around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period

Table 5. Summary of 1973 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built

Facility	Number of samples with cobalt-60			Total bottom area with cobalt-60 over 3 pCi/g[c] (km²)	Estimated total cobalt-60 in top layer of sediment[d] (Ci)
	<3 (pCi/g)[a]	3–30 (pCi/g)[b]	>30–300 (pCi/g)		
Portsmouth, N.H.; Naval Shipyard	175	0	0	0	ND
Groton, New London, Conn; Electric Boat Division, State Pier and Submarine Base	384	22	0	0.1	0.02
Newport News, Va; Newport News Shipbuilding	152	0	0	0	ND
Norfolk, Va; Naval Shipyard and Base	344	0	0	0	ND
Charleston, S.C.; Naval Shipyard and Bases	416	0	0	0	ND
Pascagoula, Miss; Ingalls Nuclear Division	213	0	0	0	ND
San Diego, Calif; Navy Piers at Ballast Point	140	0	0	0	ND
Long Beach, Calif; Naval Shipyard and Base	160	0	0	0	ND
Vallejo, Calif; Mare Island Naval Shipyard	228	0	0	0	ND
Bremerton, Wash; Naval Shipyard and Base	212	0	0	0	ND
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	351	1	0	.001	ND
Apra Harbor, Guam	109	0	0	0	ND
Port Canaveral, Fla	60	0	0	0	ND

[a] Minimum detectable radioactivity is approxiately 1 pCi/g wet weight. Results in units of pCi/cm² range from 2 to 4 times the value of pCi/g.

[b] Maximum radioactivity in these samples was 19 pCi/g.

[c] One square kilometer is approximately equal to 0.4 square mile. Areas with cobalt-60 over 3 pCi/g were in immediate vicinity of piers used for berthing nuclear-powered ships.

[d] Where total cobalt-60 in the surface sediment layer is less than 0.01 curie, ND is reported. Samples more than 1 foot deep from several harbors show that total cobalt-60 present may be 2 to 5 times that measured in the surface layer.

of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than 0.1 curie of cobalt-60. This radioactivity is small compared to background, since the quantity of naturally occurring radioactivity such as potassium-40, radium, uranium and thorium present in the sediment of a typical harbor amounts to hundreds of curies. Comparison to previous environmental monitoring data in references *8* through *15* shows that these environmental cobalt-60 levels have been steadily decreasing.

The first data column in table 5 includes all samples with less than 3 picocuries of cobalt-60 per gram of sediment. These low levels are difficult to measure because the levels of radioactivity in sediment from other sources are much higher. The value of 30 picocuries per gram was selected for the top of the second range of data since it corresponds to the upper limit for exposure in references *1* and *3*, even if consumed continuously by members of the general public. Although sediment cannot be consumed by humans, it might serve as a food source for marine life. Data on uptake of cobalt-60 by marine life obtained to date show that in the salt water harbor bottom environments, no significant buildup of cobalt-60 occurs in marine life. EPA evaluation in reference *23* shows that the cobalt-60 is in the form of metallic corrosion product particles which do not appear to be assimilated or transmitted in the food chain. The third range of up to 300 picocuries per gram is selected as a range which would not cause members of the general public to receive radiation exposure approaching the values set in references *1–4*. Concentrations of cobalt-60 up to 300 picocuries per gram are so low that the AEC does not require those who might possess them to be licensed. If concentrations higher than 300 picocuries per gram were to persist over substantial areas of a harbor bottom, further monitoring would be performed to determine if any of this radioactivity were being taken up by marine life for eventual consumption in food. Because of the low concentrations noted in table 5, monitoring of radioactivity in marine life has not been necessary as part of routine environmental monitoring programs in these harbors.

Estimates of the radiation exposure to members of the general public from radioactivity released into river and harbor waters and sediment and in air exhausted from facilities have been made as discussed in references *16* and *25* by analyzing the pathways whereby radioactivity might be transmitted from the marine environ-

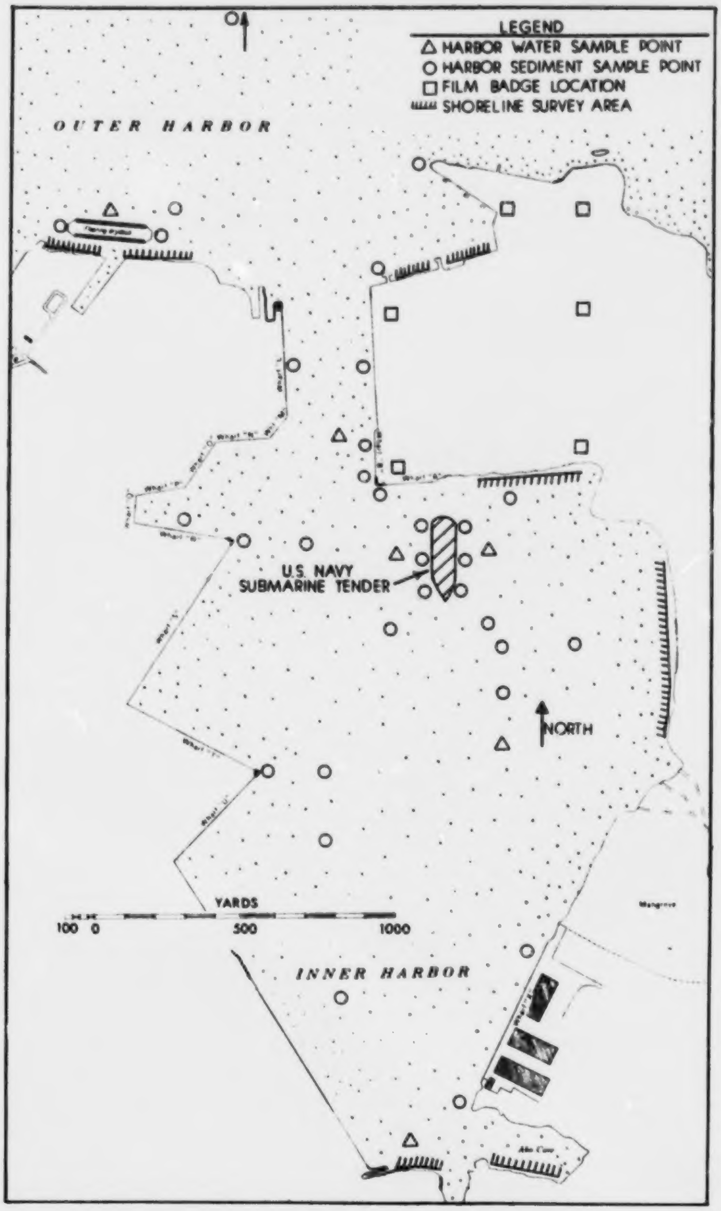
LEGEND
△ HARBOR WATER SAMPLE POINT
○ HARBOR SEDIMENT SAMPLE POINT
□ FILM BADGE LOCATION
ıııı SHORELINE SURVEY AREA
OUTER HARBOR
U.S. NAVY SUBMARINE TENDER
NORTH
YARDS
100 0 500 1000
INNER HARBOR
Mangrove
Aba Cove

Figure 12. Environmental monitoring survey chart, Mariannas, Guam

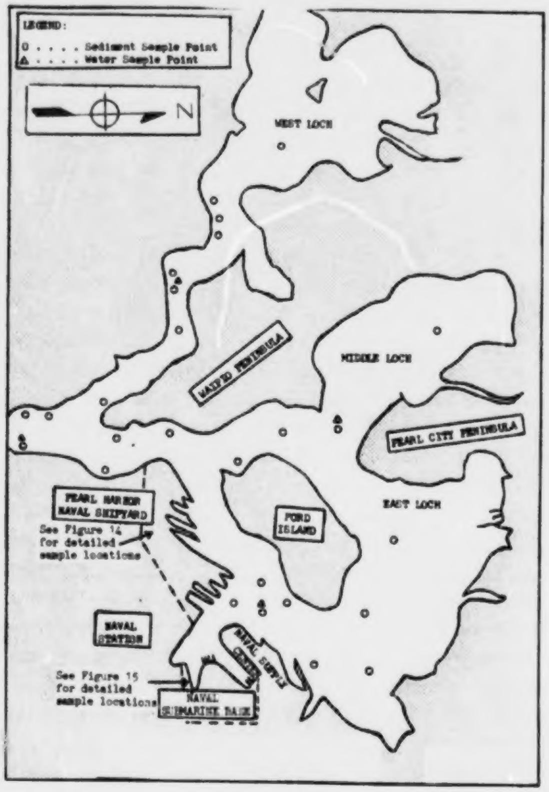
LEGEND:
O . . . . Sediment Sample Point
△ . . . . Water Sample Point
N
WEST LOCH
WAIPIO PENINSULA
MIDDLE LOCH
PEARL CITY PENINSULA
PEARL HARBOR NAVAL SHIPYARD
See Figure 14 for detailed sample locations
FORD ISLAND
EAST LOCH
NAVAL STATION
NAVAL SUPPLY CENTER
See Figure 15 for detailed sample locations
NAVAL SUBMARINE BASE

Figure 13. Overall map of Pearl Harbor, showing environmental monitoring locations in other areas of Pearl Harbor

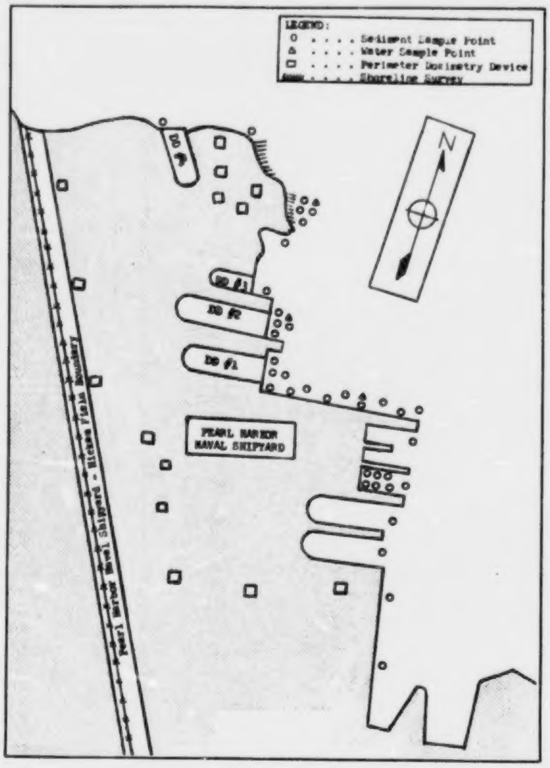
LEGEND:
O . . . . Sediment Sample Point
△ . . . . Water Sample Point
□ . . . . Perimeter Dosimetry Device
. . . . Shoreline Survey
N
DD #4
DD #3
DD #2
DD #1
PEARL HARBOR NAVAL SHIPYARD
Pearl Harbor Naval Shipyard - Hickam Field Boundary

Figure 14. Environmental monitoring locations, Pearl Harbor Naval Shipyard

ment to man. These analyses considered direct exposure, such as to sediment along shorelines and by drinking harbor water, and indirect pathways such as consumption of bottom feeding fish or shellfish. These analyses showed that personal exposure from this radioactivity would be far too low to measure and could only be estimated. Based on radioactivity released, including the amounts and concentrations reported in table 2, the maximum radiation exposure in a year to any member of the general public would be less than 0.01 mrem. This is less than one ten-thousandth of the average annual exposure of 125 mrem (*7*) to members of the general public from natural radioactivity or from exposure to medical diagnostic x-rays. Reference *26* contains proposed guidelines for effluents from water-cooled nuclear power reactors including more restrictive exposure limits of 5 mrem per year for members of the public outside the facility. These new guidelines do not apply to nuclear-powered ships and support facilities; however, the dose from radioactivity releases from these facilities as estimated above is far less than the new guidelines.

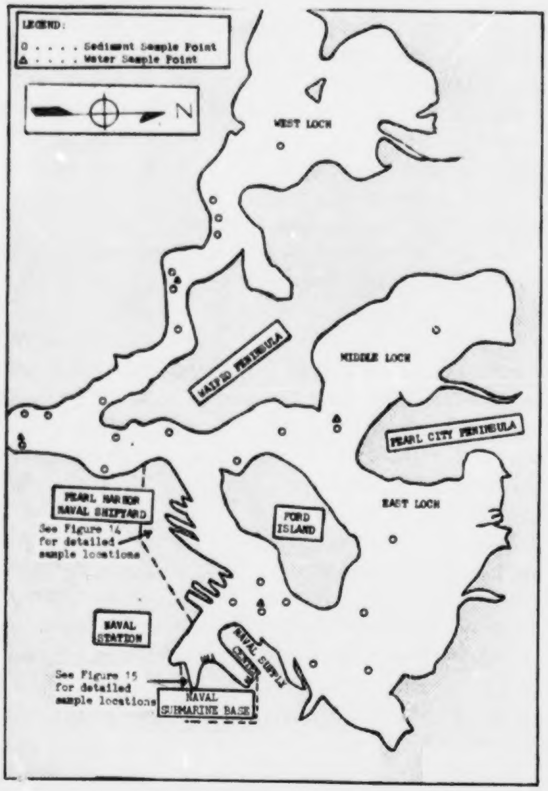
LEGEND:
O . . . . Sediment Sample Point
△ . . . . Water Sample Point
N
WEST LOCH
WAIPIO PENINSULA
MIDDLE LOCH
PEARL CITY PENINSULA
PEARL HARBOR NAVAL SHIPYARD
See Figure 14 for detailed sample locations
FORD ISLAND
EAST LOCH
NAVAL STATION
NAVAL SUPPLY CENTER
See Figure 15 for detailed sample locations
NAVAL SUBMARINE BASE

Figure 13. Overall map of Pearl Harbor, showing environmental monitoring locations in other areas of Pearl Harbor

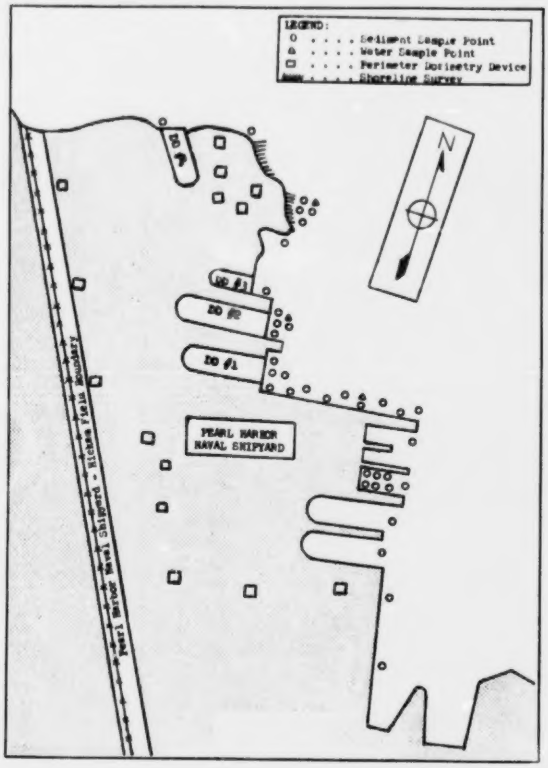
LEGEND:
O . . . . Sediment Sample Point
△ . . . . Water Sample Point
□ . . . . Perimeter Dosimetry Device
. . . . Shoreline Survey
N
DD #3
DD #1
DD #2
DD #1
PEARL HARBOR NAVAL SHIPYARD
Pearl Harbor Naval Shipyard - Hickam Field Boundary

Figure 14. Environmental monitoring locations, Pearl Harbor Naval Shipyard

ment to man. These analyses considered direct exposure, such as to sediment along shorelines and by drinking harbor water, and indirect pathways such as consumption of bottom feeding fish or shellfish. These analyses showed that personal exposure from this radioactivity would be far too low to measure and could only be estimated. Based on radioactivity released, including the amounts and concentrations reported in table 2, the maximum radiation exposure in a year to any member of the general public would be less than 0.01 mrem. This is less than one ten-thousandth of the average annual exposure of 125 mrem (*7*) to members of the general public from natural radioactivity or from exposure to medical diagnostic x-rays. Reference *26* contains proposed guidelines for effluents from water-cooled nuclear power reactors including more restrictive exposure limits of 5 mrem per year for members of the public outside the facility. These new guidelines do not apply to nuclear-powered ships and support facilities; however, the dose from radioactivity releases from these facilities as estimated above is far less than the new guidelines.

18

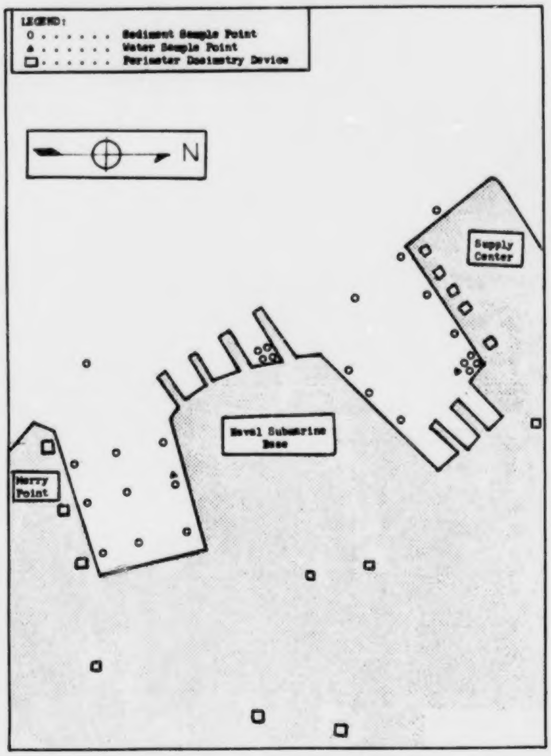
LEGEND:
O . . . . Sediment Sample Point
▲ . . . . Water Sample Point
□ . . . . Perimeter Dosimetry Device
N
Supply Center
Naval Submarine Base
Merry Point

Figure 15. Environmental monitoring locations, Pearl Harbor Naval Submarine Base

For comparison, references *27* and *28* contain evaluations by AEC laboratories of the effects on the environment from the accumulation near points of discharge of radionuclides from several nuclear reactors. These reports conclude for these other reactors that radioactivity levels much greater than shown in table 5 have caused no significant radiation exposure to the general public.

In all monitored harbors, shoreline areas uncovered at low tide are surveyed twice per year for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were the same as background radiation levels in these regions, approximately 0.01 millirem per hour. Thus, there is no evidence in these ports that radioactivity from sediment is washing ashore.

Sensitive dosimeters are continuously posted at locations outside the boundaries of areas where radioactive work is performed. These dosimeters showed that radiation exposure to the general public from radioactive work on Naval nuclear propulsion plants within these facilities was not above that received from natural background radiation levels.

Naval nuclear reactors and their support facilities are designed to ensure there are no significant discharges of radioactivity in air-

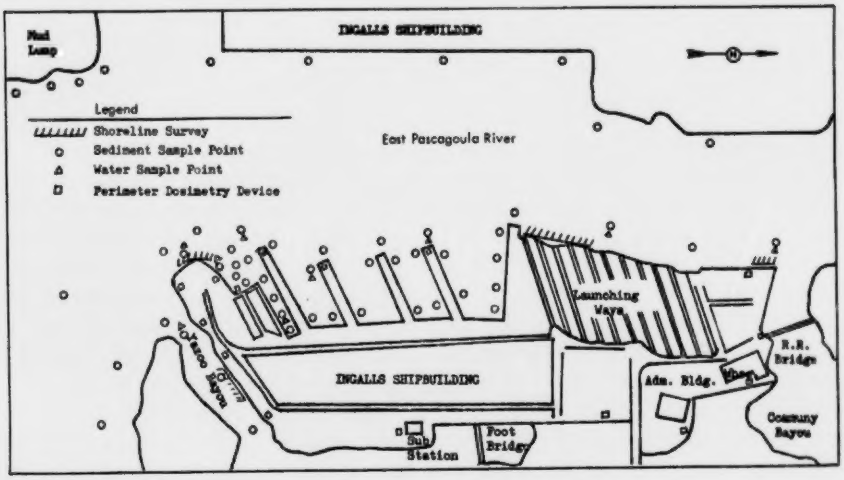
Mud Lump
INGALLS SHIPBUILDING
N
Legend
Shoreline Survey
Sediment Sample Point
Water Sample Point
Perimeter Dosimetry Device
East Pascagoula River
Launching Ways
Yazoo Bayou
INGALLS SHIPBUILDING
Adm. Bldg.
Whse.
R.R. Bridge
Sub Station
Foot Bridge
Communy Bayou

Figure 16. Ingalls Shipbuilding environmental monitoring survey

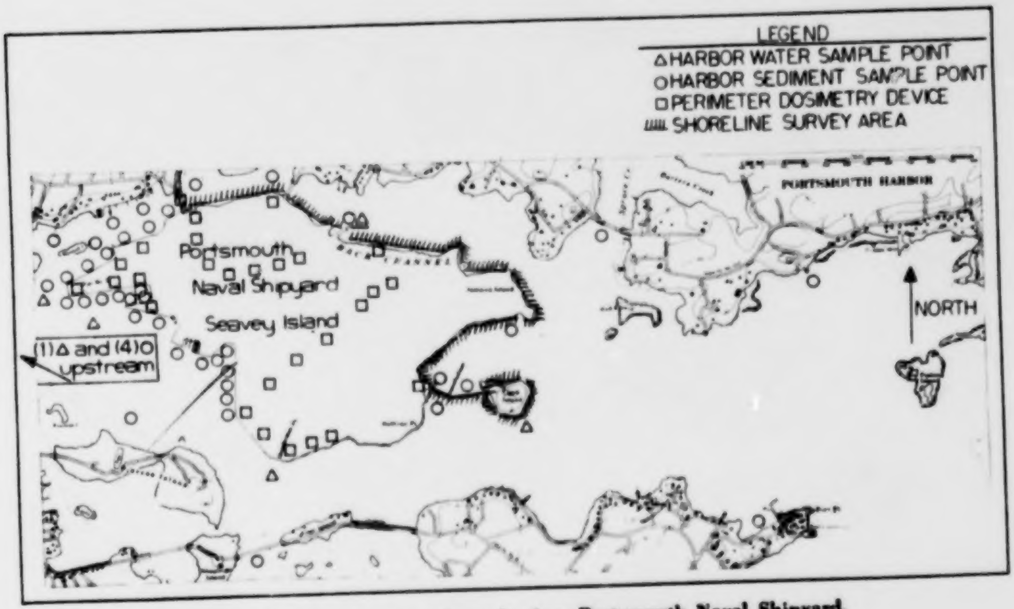
LEGEND
Δ HARBOR WATER SAMPLE POINT
○ HARBOR SEDIMENT SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
SHORELINE SURVEY AREA
PORTSMOUTH HARBOR
Portsmouth
Naval Shipyard
Seavey Island
(1)Δ and (4)○
upstream
NORTH

Figure 17. Environmental monitoring, Portsmouth Naval Shipyard, Portsmouth-Kittery harbor

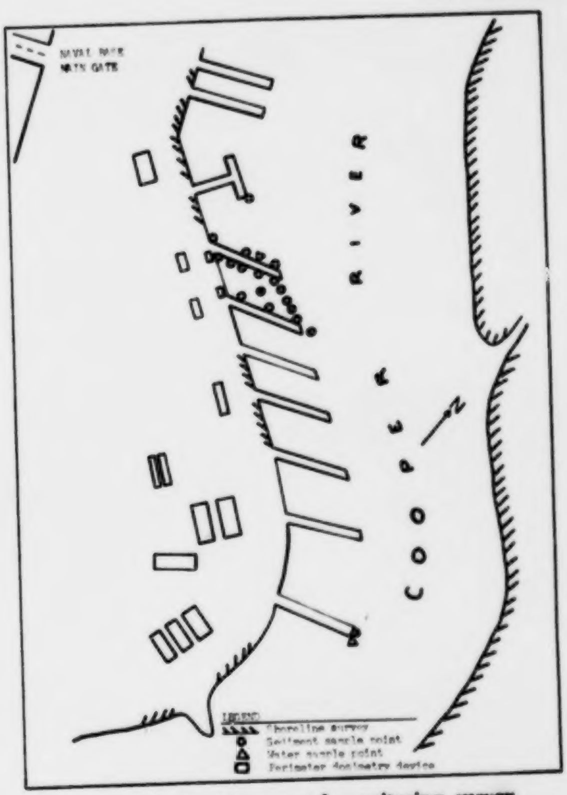
NAVAL BASE
MAIN GATE
RIVER
COOPER
N
LEGEND
Shoreline survey
Sediment sample point
Water sample point
Perimeter dosimetry device

Figure 18. Environmental monitoring survey, Charleston Naval Station

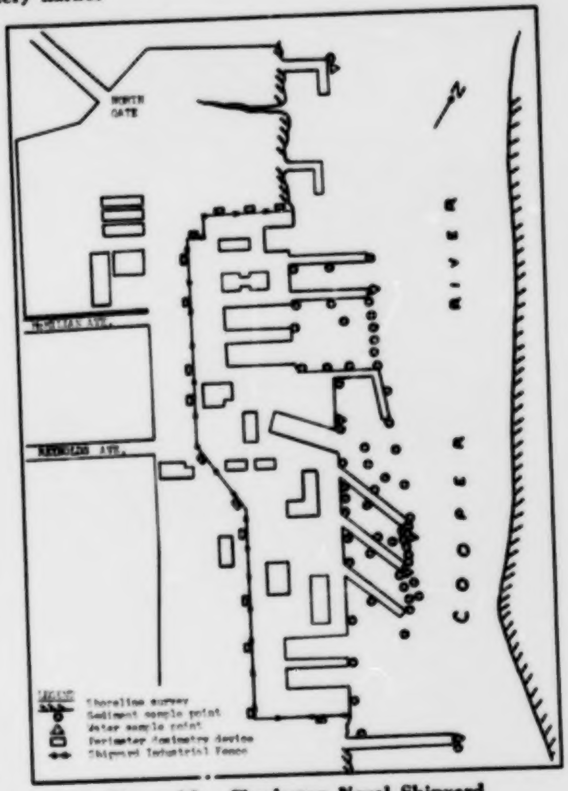
NORTH
GATE
McMILLAN AVE.
REYNOLDS AVE.
RIVER
COOPER
N
LEGEND
Shoreline survey
Sediment sample point
Water sample point
Perimeter dosimetry device
Shipyard Industrial Fence

Figure 19. Charleston Naval Shipyard

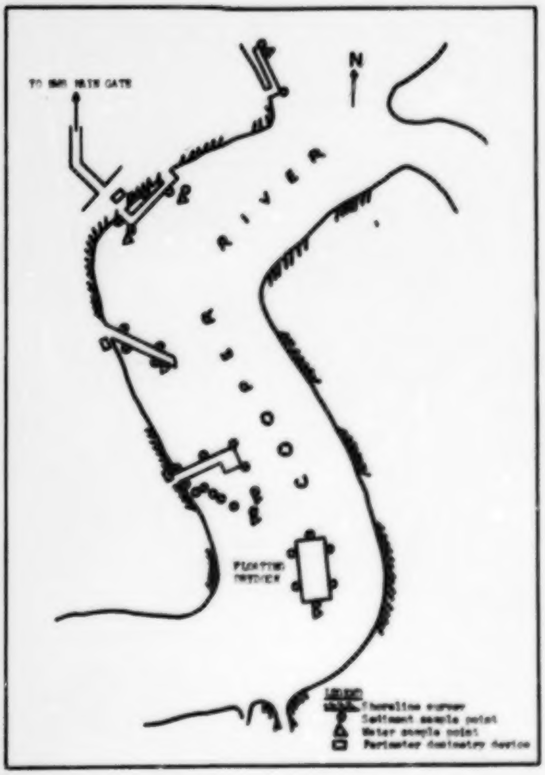
TO NWS MAIN GATE
N
RIVER
COOPER
FLOATING DRYDOCK
LEGEND
Shoreline survey
Sediment sample point
Water sample point
Perimeter dosimetry device

Figure 20. Naval Weapons Station, Charleston, S.C.

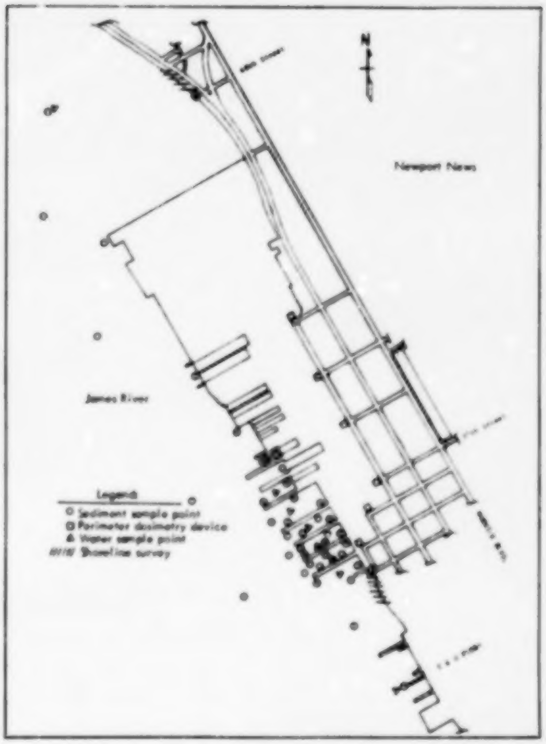
N
Newport News
James River
Legend
Sediment sample point
Perimeter dosimetry device
Water sample point
Shoreline survey

Figure 21. Environmental monitoring survey locations, Newport News Shipbuilding and Dry Dock Company

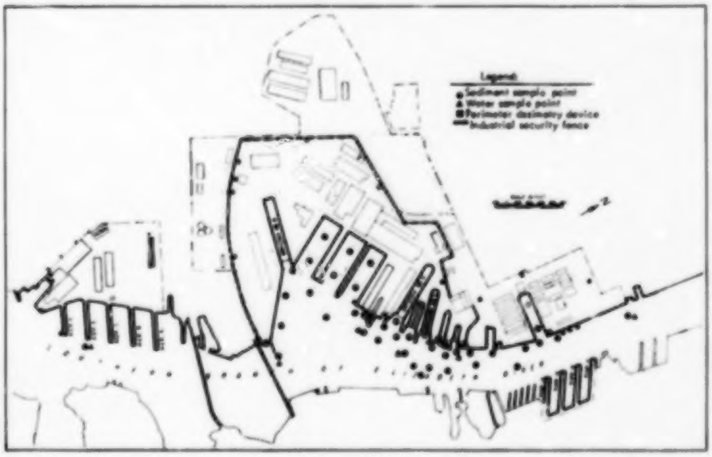
Legend
Sediment sample point
Water sample point
Perimeter dosimetry device
Industrial security fence
N

Figure 22. Environmental monitoring, Norfolk Naval Shipyard, Portsmouth, Va.

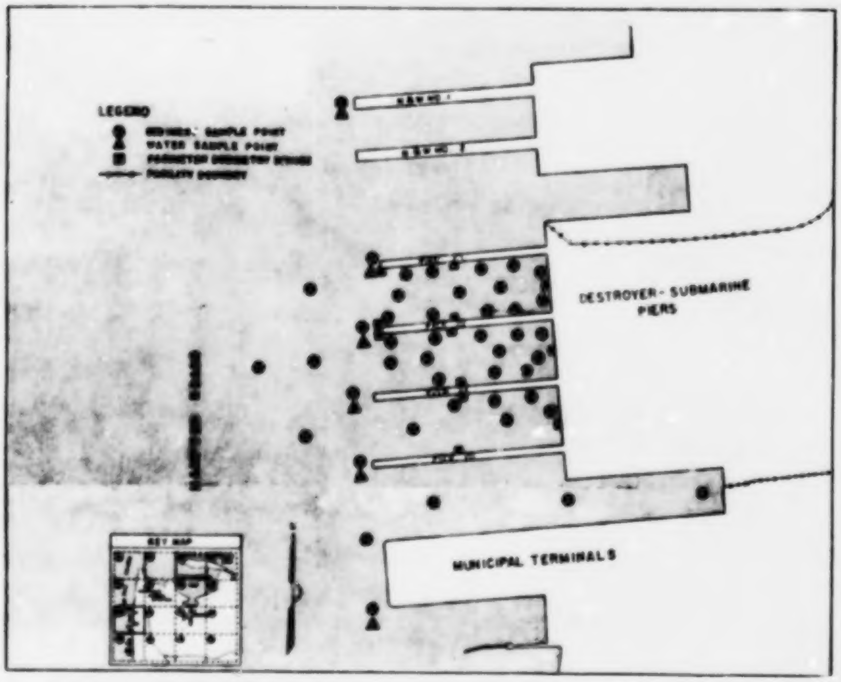
LEGEND
SAMPLE POINT
WATER SAMPLE POINT
DESTROYER- SUBMARINE PIERS
MUNICIPAL TERMINALS
KEY MAP

Figure 23. Norfolk Naval Station, destroyer, and submarine piers, Norfolk, Va.

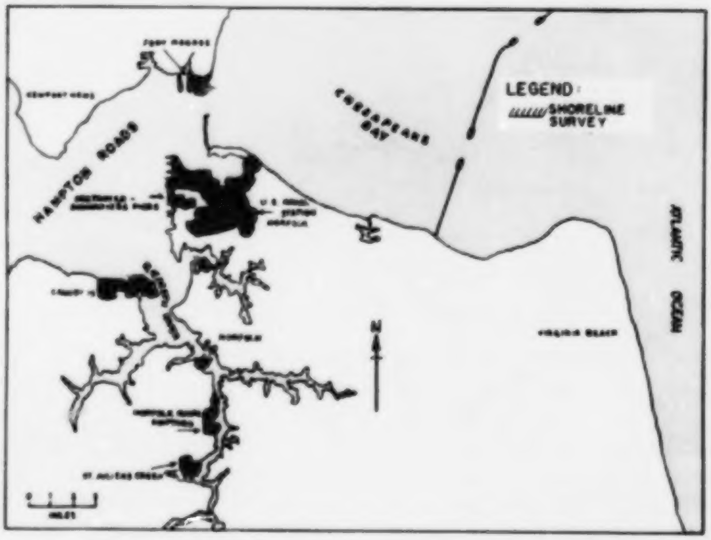
FORT MONROE
NEWPORT NEWS
HAMPTON ROADS
CHESAPEAKE BAY
LEGEND:
SHORELINE SURVEY
U.S. NAVAL STATION NORFOLK
NORFOLK
ATLANTIC OCEAN
VIRGINIA BEACH
N
MILES

Figure 24. Shoreline radiation survey locations, Norfolk, Va.

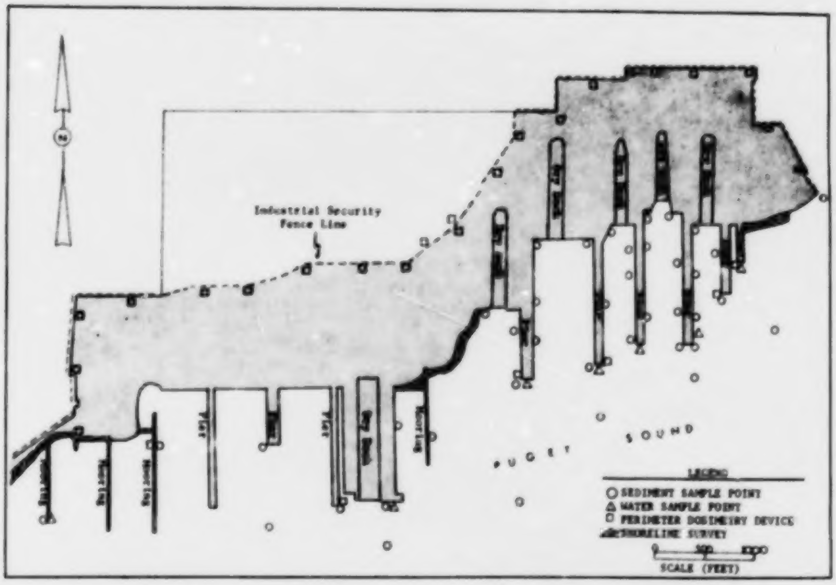
Industrial Security Fence Line
Pier
Dry Dock
Mooring
PUGET SOUND
LEGEND
○ SEDIMENT SAMPLE POINT
△ WATER SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
SHORELINE SURVEY
0 500 1000
SCALE (FEET)

Figure 25. Environmental monitoring locations, Puget Sound Naval Shipyard, Bremerton, Wash.

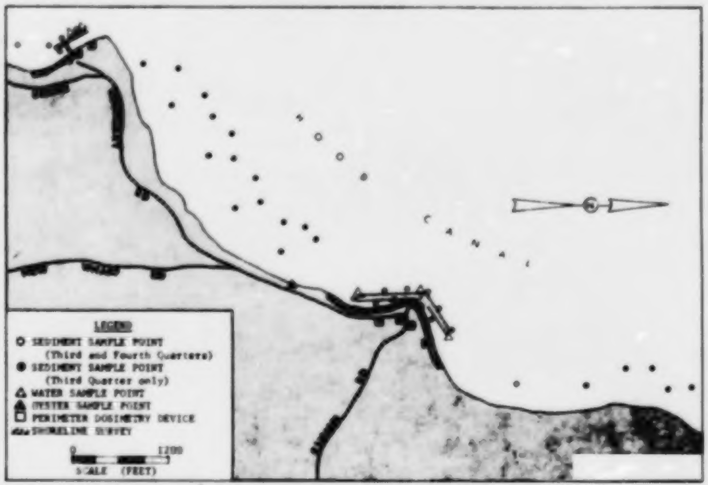
HOOD CANAL
LEGEND
○ SEDIMENT SAMPLE POINT (Third and Fourth Quarters)
● SEDIMENT SAMPLE POINT (Third Quarter only)
△ WATER SAMPLE POINT
▲ OYSTER SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
SHORELINE SURVEY
0 1200
SCALE (FEET)

Figure 26. Environmental monitoring locations, Hood Canal, Bangor, Wash.

borne exhausts. Radiological controls are exercised in support facilities to preclude exposure of working personnel to airborne radioactivity exceeding limits such as specified in reference *1*. Further, all air exhausted from these facilities is passed through high efficiency particulate air filters and monitored during discharge. There were no discharges in airborne radioactivity above concentrations normally present in the atmosphere.

Conclusions

The total radioactivity, less tritium, released into all ports and harbors from the U.S. Naval nuclear propulsion program was less than 0.002 curie in 1973. The total tritium released into all ports and harbors was less than 1 curie in 1973.

No increase of radioactivity above normal background levels has been detected in harbor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

Liquid wastes from U.S. Naval nuclear-powered ships and support facilities have not caused a measurable increase in the general background radioactivity of the environment.

Low-level cobalt-60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor of less than 0.1 curie of cobalt-60 is small compared to the naturally occurring radioactivity. Comparison to previous environmental data summarized in references *8* through *15* shows that these environmental cobalt-60 levels are continuing to decrease.

Procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public.

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(*1*) Code of Federal Regulations, Title 10 (Atomic Energy Commission) Part 20, Standards for protection against radiation.

(*2*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure, Report No. 22. NBS Handbook 69, National Bureau of Standards (June 1959).

(*3*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, Report of Committee II on permissible dose for internal radiation, Publication 2 (1959); 1962 supplement of ICRP Publication 6; Recommendations on radiation exposure, ICRP Publication 9 (1965); and ICRP Publication 7 (1965), amplifying specific recommendations of Publication 9 concerning environmental monitoring.

(*4*) Federal Radiation Council Memoranda, approved by President Eisenhower on May 13, 1960, President Kennedy on September 20, 1961, and President Johnson on July 31, 1964.

(*5*) NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL. Radioactive waste disposal from nuclear-powered ships, Publication 658. National Research Council, Washington, D.C. (1959).

(*6*) INTERNATIONAL ATOMIC ENERGY AGENCY. Radioactive waste disposal into the sea, Safety Series No. 5, Vienna (1961).

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(*8*) VAUGHAN, J. W. and M. E. MILES. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1965. Radiol Health Data Rep 7:257–262 (May 1966).

(*9*) MILES, M. E. and J. J. MANGENO. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1966. Radiol Health Data Rep 8:699–701 (December 1967).

(*10*) MILES, M. E. and J. J. MANGENO. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1967. Radiol Health Data Rep 10:135–138 (April 1969).

(*11*) MILES, M. E. and J. J. MANGENO. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1968. Radiol Health Data Rep 10:375–377 (September 1969).

(*12*) MANGENO, J. J. and M. E. MILES. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1969. Radiol Health Data Rep 11:373–377 (August 1970).

(*13*) MILES, M. E., J. J. MANGENO, and R. D. BURKE. Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1970. Radiol Health Data Rep 12:235–244 (May 1971).

(*14*) MILES, M. F., G. L. SJOBLOM, and R. D. BURKE. Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1971. Radiat Data Rep 9:469–478 (September 1972).

(*15*) MILES, M. E. and G. L. SJOBLOM. Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1972. Radiat Data Rep 9:717–725 (September 1973).

(*16*) NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL. Radioactivity in the marine environment (1971).

(*17*) JACOBS, D. G. Sources of tritium and its behavior upon release to the environment, TID–24635. U.S. Atomic Energy Commission (1968).

(*18*) LOGSDON, J. E. and R. I. CHISSLER. Radioactive waste discharges to the environment from nuclear power facilities, BRH/DER 70–2. U.S. Public Health Service (March 1970).

(*19*) LOGSDON, J. E. Radioactive waste discharges to the environment from nuclear power facilities. Radiat Data Rep 13:117–130 (March 1973).

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Radionuclides in Foods: Monitoring Program

R. E. Simpson, E. J. Baratta, and C. F. Jelinek[1]

In January 1973, the Food and Drug Administration notified its food monitoring program to include the radionuclides strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Samples from eight composite food categories from each of eight separate total diet market baskets plus eight imported commodities from each of 13 separate cities were forwarded to the Winchester Engineering and Analytical Center for analysis. This paper describes the market basket program and gives a breakdown of the types of foods and quantities of each.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides.

In 1961, the Food and Drug Administration (FDA) initiated a program to monitor radioactivity, nutrients, and pesticides in the teenage total diet (*1,2*). This was expanded in 1964 to include the analysis for trace elements (*3*). In addition to the FDA, six other Federal, State and private organizations have conducted monitoring programs for radionuclides in foods in the past (*4*). A statistical study of data reported under these programs indicated all participating organizations were obtaining concordant results, which showed that the radioactivity levels in foods were below levels that would require protective action, and were declining as a result of the Test Ban Treaty. Because of this downward trend, and to prevent duplication of effort, FDA decided in 1969 to discontinue monitoring radionuclides in foods.

In accordance with the President's Reorganization Plan 3 of June 1970, the Institutional Diet Program (*5*) of the Bureau of Radiological Health was transferred to the Radiation Office of the Environmental Protection Agency (EPA). Since the low levels of radioactivity being observed approached the limits of analytical sensitivity, this program was cancelled by EPA in 1973.

With the projected growth of nuclear power and the resultant impact upon ecological systems, the monitoring for radioactivity within the environs and food-producing locations around reactor facilities becomes of increasing concern. There were, at the end of 1973, 96 nuclear plants either under construction or in operation in this country alone. It is anticipated that by the end of the century this number will be more than doubled (*6*). Therefore, in January 1973, the Office of the Commissioner, FDA, decided that a radiochemical analytical capability should be maintained by the FDA to perform and evaluate necessary analysis of foods in the event of a radiological incident and to note any upward trends in radioactive contamination of food that might develop (*7*).

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This program includes the analysis of strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40, a naturally-occurring radionuclide.

Sample collections

For the purposes of the sampling program, "import" commodities are restricted to imported foods which have the domestic status indicated in table 1. "Total diet" is defined as representative food and drink consumed by a teenage male living in a moderate income family (*1*). The market basket shopping list, appendix A, is based upon the latest survey of the United States household consumption conducted by the U.S. Department of Agriculture (USDA) in 1965 (*8*).

Diet guides are provided for each of four geographic regions of the United States as defined by the USDA: Southeastern, Northeastern, Central, and Western. Each market basket represents the recommended 2-week diet of a 15–20 year old male for the region in which it is collected. It should be noted that appendix A reflects the diet for the Northeastern region. Diets for the other regions vary slightly from this.

Table 1. Commodities collected for import surveillance

Imported foods[a]	Remarks
1. Seafish, including shrimp	May be frozen or canned. The label should indicate foreign origin.
2. Cheese	The label should indicate foreign origin.
3. Fresh fruit, including bananas	Exclude pineapple from Hawaii.
4. Canned fruit, including pineapple	Same as 3 above.
5. Tea	A foreign origin label is preferred but "domestic" product may be substituted as necessary.
6. Coffee	Same as 5 above.
7. Cocoa powder	Same as 5 above.
8. Cashew nuts	Same as 5 above.

[a] A minimum of 2 pounds of each product.

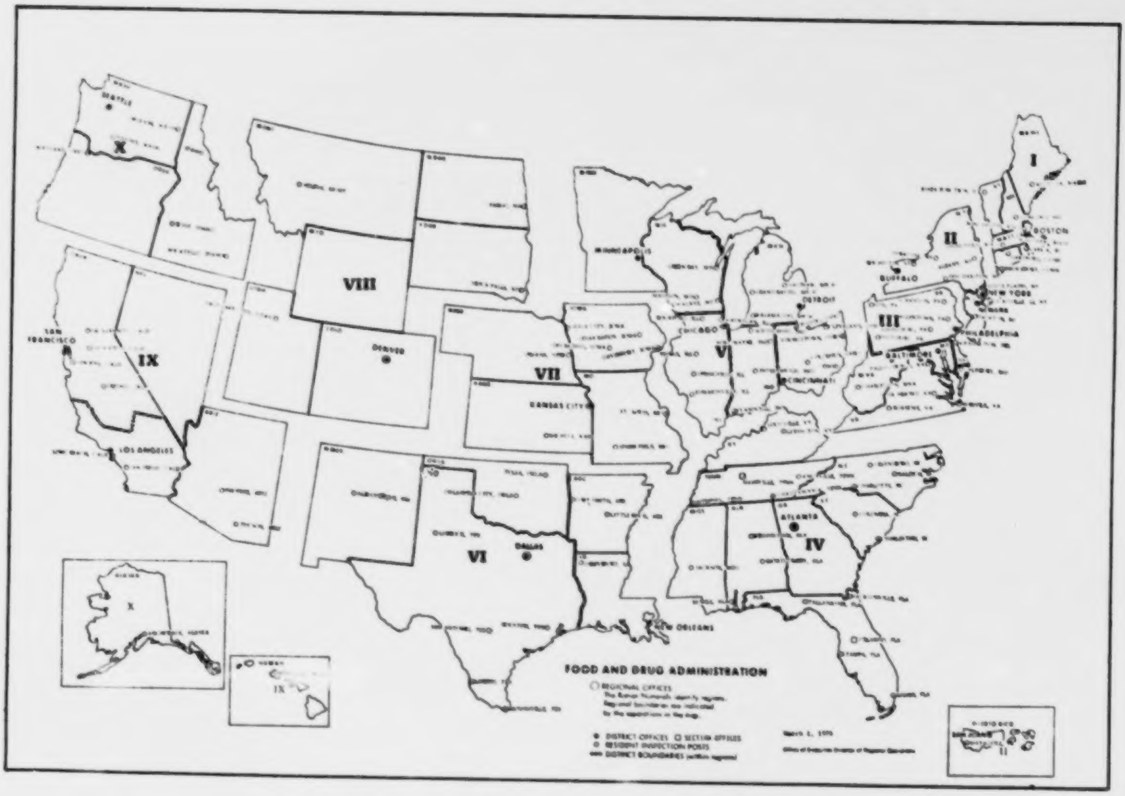
I
II
III
IV
V
VI
VII
VIII
IX
X
SEATTLE
SAN FRANCISCO
LOS ANGELES
DENVER
KANSAS CITY
DALLAS
MINNEAPOLIS
CHICAGO
DETROIT
CINCINNATI
BUFFALO
BOSTON
NEW YORK
PHILADELPHIA
BALTIMORE
ATLANTA
NEW ORLEANS
FOOD AND DRUG ADMINISTRATION
REGIONAL OFFICES
DISTRICT OFFICES
SECTION OFFICES
RESIDENT INSPECTION POSTS
DISTRICT BOUNDARIES (within regions)

Figure 1. The Food and Drug Administration Regions and districts

The FDA inspectors from Boston, Buffalo, New York, Baltimore, Atlanta, New Orleans, Kansas City, Minneapolis, San Francisco, and Los Angeles collected samples within the Regions and Districts indicated in figure 1. The collection sites used in Fiscal Year 1973 are shown in tables 2 and 3. All import samples and market baskets collected by the designated FDA Districts were forwarded to the Kansas City Field Laboratory for processing and distribution (*3*). Each of the commodities of the market basket samples which are not normally eaten raw was prepared in a university dietary kitchen (under contract with the FDA) and then composited into the categories indicated in appendix A. The import commodities were handled separately. Portions of each of the eight total diet composites as well as the separate import products were forwarded from Kansas City to the Winchester Engineering Analytical Center (WEAC) for radionuclide analysis.

Procedures

Each of the samples is analyzed for strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Cesium-137, iodine-131, ruthenium-106, and potassium-40 concentrations were determined by gamma-ray spectroscopy (*9*) and the gamma spectra were examined qualitatively for evidence of other gamma-emitting radionuclides. The strontium-90 is determined by beta-counting the daughter product, yttrium-90 (*10*). For purposes of quality control, selected samples are analyzed as blind duplicates.

All concentrations equal to or less than the minimum detectable limit of the appropriate radionuclide are reported as "not detectable" (ND). The minimum detectable limit is the concentration equal to the two-standard-deviation analytical error (*11*). For the radionuclides included in this report, the minimum detectable limits are: strontium-90, 0.5 pCi/kg; iodine-131, 10 pCi/kg; cesium-137, 10 pCi/kg; ruthenium-106, 10 pCi/kg; and potassium-40 expressed as 0.05 g stable potassium per kg of sample.

Discussion and results

In past monitoring programs, no consideration was given to the radioactivity levels in various imported food products. In order to determine whether there are any differences between radioactivity levels in such food products and domestic produce, the FDA included the eight import food items listed in table 1 in its monitoring program. Seafood is known to concentrate certain radionuclides (e.g., shellfish concentrate cesium-137 and cobalt-60) and therefore, should be early "indicators" of changes in radioactivity levels in marine foodstuffs of foreign origin. Cheese was selected as a possible indicator of levels of radioactivity in foreign milk products, while the fruits, nuts, tea, coffee and cocoa serve as examples of foreign produce where surface contamination may result from changes in environmental radioactivity.

Based upon an assumed average food consumption rate of 1.71 kg/day and the Radiation Protection Guides (RPG) recommended for Federal agencies by the Federal Radiation Council (FRC) (*12*), the following concentration ranges have been derived as guides applicable to foods (*13*):

	Range I (pCi/kg)	Range II (pCi/kg)	Range III (pCi/kg)
Cesium-137	0–360	360–3 600	3 600–360 000
Strontium-90	0– 20	20– 200	200– 2 000
Types of action recommended:	Periodic confirmatory surveillance	Quantitative surveillance-routine control	Evaluation and additional controls as necessary

Table 2a. Radionuclides in imported foods, canned fruit

Food type and treatment or condition	Country of origin [a]	Collection site	Collecting district (DO) or field (FO) office [b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K [c] (g K/kg)	^{90}Sr (pCi/kg)
Oranges, canned, syrup included:	Taiwan	Anaheim, Calif.	Los Angeles (LOS—DO)	1/ 2	ND	ND	ND	1.10±0.30	9.9 ±1.30
	Taiwan	Lake Charles, La.	New Orleans (NOL—DO)	1/ 8	ND	ND	ND	.81± .60	9.34±1.14
Fruit, mixed, jelled, canned	Japan	Bakersfield, Calif.	San Francisco (SAN—DO)	2/13	ND	ND	ND	ND	2.90± .70
Oranges, canned, syrup included	Taiwan	Atlanta, Ga.	Atlanta (ATL—FO)	2/26	ND	ND	ND	.94± .33	9.90±1.00
Pineapple, canned including syrup	Taiwan	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	.99± .36	2.37± .61
Pineapple, canned including syrup	Taiwan	Lafayette, La	NOL—DO	3/12	ND	ND	ND	1.30± .30	2.26± .50
Papaya and syrup, canned		Jersey City, N.J.	New York City (NYK—DO)	4/ 9	ND	ND	ND	.67± .27	3.38± .78
Oranges, mandarin, canned, syrup	Japan	Jericho, N.Y.	(NYK—DO)	4/30	ND	ND	ND	.92± .31	2.22± .58
Pineapple and syrup, canned	Mexico	Charleston, W. Va.	Baltimore (BAL—DO)	5/ 7	ND	ND	ND	1.74± .33	4.50± .80
Pineapple+oranges+syrup canned	Japan	New Britain, Conn.	Boston (BOS—FO)	6/11	ND	ND	ND	.99± .32	2.44± .56
Mandarin oranges, canned	Japan	Alliance, Nebr.	Kansas City, Kans. (KAN—DO)	6/20	ND	ND	ND	.79± .31	1.95± .66
Oranges and syrup, canned	Japan	Beloit, Wis.	Minneapolis MIN—DO	7/10	ND	ND	25±22	1.20± .30	4.20± .70
Average, $\bar{x}$							25	1.04	4.61
2 $S\bar{x}$, among [d]								0.18	1.83
$2\sigma\bar{x}$, counting error [e]							22	0.11	0.24
n							1	11	12

See footnotes at end of table.

Table 2b. Radionuclides in imported foods, fresh fruit

Food type and treatment or condition	Country of origin [a]	Collection site	Collecting district or field office [b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K [c] (g K/kg)	^{90}Sr (pCi/kg)
Bananas	Costa Rica	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	3.38±0.4	ND
Bananas		Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	4.43± .4	ND
Bananas	Costa Rica	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	ND	2.86± .37	1.8 ±0.7
Bananas	Costa Rica	Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	3.05± .37	.74± .6
Bananas		Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	4.2 ± .5	.67± .50
Bananas		Lafayette, La.	NOL—DO	3/12	ND	ND	ND	3.2 ± .4	.54± .50
Honeydew melon	Mexico	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	2.74± .35	ND
Pears, fresh	Victoria, Austrailia	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	ND	1.07± .34	1.26± .54
Bananas	Ecuador	Alliance, Nebr.	KAN—DO	6/20	ND	ND	ND	4.02± .42	ND
Bananas	Ecuador	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	3.50± .39	.54± .44
Bananas	Ecuador	Beloit, Wis.	MIN—DO	7/10	ND	ND	ND	3.7 ± .4	.58± .54
Average, $\bar{x}$								3.29	0.87
2 $S\bar{x}$, among [d]								0.55	0.36
$2\sigma\bar{x}$, counting error [e]								0.12	0.2
n								11	7

See footnotes at end of table.

These ranges conform to the FRC guides concerning transient rates of daily intake of radionuclides. The values are an adjunct to the guides applied in the EPA-FDA milk surveillance program (*14*) and are based upon an RPG dose of 0.17 rad/year to suitable samples of the population for the bone marrow dose from strontium-90 and 0.17 rad/year whole-body dose due to cesium-137.

For purposes of the evaluation it was conservatively assumed that each of the commodities of imported samples or total diet composites would be consumed at the rate of 1.71 kg/day for comparison with the above range limitations.

The results of the imported food survey presented in tables 2a through 2h show no iodine-131 or ruthenium-106 present within detectable limits in any of the individual food samples, and no detectable cesium-137 in fruit, both

Table 2c. Radionuclides in imported foods, fish

Food type and treatment or condition	County of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Shrimp	Mexico	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	32 ±24	1.67 ±0.90	ND
Shrimp	Taiwan	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	1.42 ± .50	0.9 ±0.64
Kipp, herring (canned)	Scotland	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	38 ±24	4.82 ± .42	2.4 ± .90
	Scotland	Atlanta, Ga.	ATL—FO	2/26	ND	ND	81 ±24	3.79 ± .40	3.4 ±1.0
Mackerel, canned	Japan	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	3.20 ± .40	.80 ± .64
Kipp, herring (canned)	Scotland	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	35 ±22	4.00 ± .40	1.81 ± .82
Fish, canned	Israel	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	1.50 ± .34	5.4 ± .86
Kipp, herring	Scotland	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	232 ±17	3.40 ± .40	2.7 ± .90
Tuna, canned	Japan	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	2.53 ± .38	ND
Herring fillet	W. Germany	Alliance, Nebr.	KAN—DO	6/20	ND	ND	49 ±29	1.68 ± .44	ND
Mackerel, canned	Japan	Beloit, Wisc.	MIN—DO	7/10	ND	ND	26 ±22	3.40 ± .40	2.30 ± .80
Average, $\bar{x}$							70.4	2.9	2.45
2 $S_{\bar{x}}$, among[d]							55.6	0.7	1.04
2$\sigma_{\bar{x}}$, counting error[e]							8.8	0.14	0.29
n							7	11	8

See footnotes at end of table.

Table 2d. Radionuclides in imported foods, cheese

Food type and treatment or condition	Country of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Cheese, feta	Denmark	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	ND	0.68 ±0.30	19.80 ±1.60
Cheese, semisoft	France	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	ND	43.60 ±2.20
Cheese	France	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	ND	.80 ± .30	50.00 ±2.40
Cheese	Denmark	Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	.87 ± .29	5.20 ±1.00
Cheese	Denmark	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	ND	.40 ± .30	41.70 ±2.60
Cheese	Denmark	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	.40 ± .30	35.80 ±2.00
Cheese, soft	Denmark	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	.50 ± .32	44.00 ±3.00
Cheese, semisoft	Denmark	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	ND	.42 ± .30	28.70 ±2.00
Cheese	Switzerland	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	141 ±22	.66 ± .30	101.70 ±4.40
Swiss cheese	Finland	New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	.93 ± .33	80.30 ±4.10
Gruyere cheese	Switzerland	Alliance, Nebr.	KAN—DO	6/20	ND	ND	ND	.81 ± .33	83.10 ±3.70
Cheese	Denmark	Beloit, Wis.	MIN—DO	7/10	ND	ND	ND	.5 ± .3	38.8 ±2.1
Average, $\bar{x}$							141	0.63	47.7
2$S_{\bar{x}}$ among[d]								0.12	16.0
2$\sigma_{\bar{x}}$, counting error[e]							22	0.09	0.8
n							1	11	12

See footnotes at end of table.

fresh and canned. The strontium-90 levels in fruit were either below detectable limits or well within Range I of the above guides. Similar results were also indicated for all samples of imported fish.

In 10 of the 12 samples of imported cheese, the levels of strontium-90 were observed to be within Range II. With the exception of one apparent anomaly, cesium-137 was below detectable limits in all samples of cheese.

In the case of both coffee and tea, analyses were performed on both unbrewed and brewed samples. It is interesting to note that—particularly in the case of tea—the normal brewing operation was effective in significantly lowering both the cesium-137 and strontium-90 levels in the samples as brewed for normal consumption. The usual form of consumption of these commodities is in the brewed state. As such, following the previously mentioned conserv-

Table 2e. Radionuclides in imported foods, coffee

Food type and treatment or condition	Country of origin[a]	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[e] (g K/kg)	^{90}Sr (pCi/kg)
Coffee		Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	105 ±53	19.1 ±1.10	NA
Coffee, brewed				1/ 2	NA	NA	NA	NA	15.6 ±3.22
Coffee		Lake Charles, La.	NOL—DO	1/ 8	ND	ND	54 ±43	21.20 ±1.40	NA
Coffee, brewed				1/ 8	NA	NA	NA	NA	9.18 ±1.25
Coffee		Bakersfield, Calif.	SAN—DO	2/13	ND	ND	189 ±49	20.28 ±1.07	NA
Coffee, brewed				2/13	NA	NA	NA	NA	30.90 ±2.20
Coffee		Atlanta, Ga.	ATL—FO	2/26	ND	ND	ND	18.87 ±1.05	NA
Coffee, brewed				2/26	NA	NA	NA	NA	20.50 ±1.70
Coffee		Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	80 ±50	19.90 ±1.10	NA
Coffee, brewed				3/ 5	ND	ND	34 ±25	17.12 ±0.66	13.20 ±1.60
Coffee		Lafayette, La.	NOL—DO	3/12	ND	ND	ND	19.50 ±1.0	NA
Coffee, brewed				3/12	ND	ND	32 ±25	15.80 ±0.50	12.80 ±1.40
Coffee		Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	ND	21.00 ±1.10	26.40 ±2.80
Coffee, brewed				4/ 9	ND	ND	42 ±24	14.60 ±0.60	8.40 ±1.30
Coffee	Colombia	N. Massaequa, N.Y.	NYK—DO	4/24	ND	ND	ND	18.60 ±1.10	37.80 ±3.20
Coffee, brewed				4/24	ND	ND	ND	15.90 ±0.70	15.40 ±1.50
Coffee		Charleston, W. Va:	BAL—DO	5/ 7	ND	238 ±204	ND	18.10 ±1.00	24.30 ±4.00
Coffee, brewed				5/ 7	ND	ND	ND	15.20 ±0.60	10.50 ±1.30
Coffee		New Britain, Conn.	BOS—FO	6/11	ND	ND	ND	19.60 ±1.10	13.30 ±2.30
Coffee, brewed				6/11	ND	ND	ND	15.60 ±1.90	10.70 ±2.40
Coffee		Alliance, Nebr.	KAN—DO	6/20	ND	ND	75 ±49	18.40 ±1.10	27.00 ±2.90
Coffee, brewed				6/20	ND	ND	54 ±26	16.50 ±0.70	11.60 ±1.40
Coffee	Colombia	Beloit, Wisc.	MIN—DO	7/10	ND	ND	94 ±50	17.50 ±1.00	16.70 ±2.30
Average, $\bar{x}$:									
Coffee							99.5	19.3	24.3
Coffee, brewed[f]							40.5	15.8	14.4
2 S$_{\bar{x}}$, among:									
Coffee							38.5	0.65	7.0
Coffee, brewed							9.98	0.62	3.9
2σ$_{\bar{x}}$, counting error:									
Coffee							20.0	0.32	1.2
Coffee, brewed							12.5	0.34	0.56
n Coffee							6	12	6
Coffee, brewed							4	7	11

See footnotes at end of table.

Table 2f. Radionuclides in imported foods, tea

Food type and treatment or condition	Collection site	Collecting district or field office[b]	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[e] (g K/kg)	^{90}Sr (pCi/kg)
Tea	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	385 ±57	22.90 ±1.20	NA
Tea, brewed[g]				ND	ND	NA	NA	22.50 ± 2.52
Tea	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	320 ±56	22.64 ±0.50	NA
Tea, brewed			1/ 8	NA	NA	NA	NA	58.2 ± 5.25
Tea, loose	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	161 ±63	19.86 ±1.26	NA
Tea, brewed			2/13	NA	NA	NA	NA	45.00 ± 5.20
Tea, loose	Atlanta, Ga.	ATL—FO	2/26	ND	ND	436 ±62	20.05 ±1.26	NA
Tea, brewed			2/26	NA	NA	NA	NA	44.6 ± 4.90
Tea, (from bags)	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	167 ±51	21.5 ±1.11	NA
Tea, brewed			3/ 5	ND	ND	135 ±62	16.60 ±1.20	25.80 ± 3.00
Tea, loose	Lafayette, La.	NOL—DO	3/12	ND	ND	366 ±55	19.80 ±1.20	NA
Tea, brewed			3/12	ND	ND	247 ±65	16.90 ±1.30	45.1 ± 3.90
Tea, (from bags)	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	325 ±54	20.50 ±1.20	593 ±18
Tea, brewed			4/ 9	ND	ND	203 ±63	15.70 ±1.20	86.80 ± 5.40
Tea, loose	Plainview, N.Y.	NYK—DO	4/25	ND	ND	276 ±57	19.50 ±1.10	472 ±15
Tea, brewed			4/25	ND	ND	250 ±67	15.70 ±1.00	26.5 ± 3.40
Tea	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	268 ±49	18.70 ±1.10	331.10 ±11.00
Tea, brewed			5/ 7	ND	ND	137 ±69	15.00 ±1.30	38.20 ± 3.70
Tea, in bags	New Britain, Conn.	BOS—FO	6/11	ND	ND	330 ±62	20.56 ±1.20	289 ±12
Tea, brewed			6/11	ND	ND	236 ±78	16.60 ±1.40	14.2 ± 2.80
Tea	Alliance, Nebr.	KAN—DO	6/20	ND	ND	231 ±63	19.90 ±1.20	400 ±14
Tea, brewed			6/20	ND	ND	169 ±80	16.10 ±1.40	35.9 ± 4.30
Tea, loose	Beloit, Wis.	MIN—DO	7/10	ND	ND	289 ±63	20.50 ±1.20	497 ±15
Average, $\bar{x}$ Tea						296.2	20.5	430.3
Tea, brewed[g]						196.7	16.1	40.3
2S$_{\bar{x}}$, among Tea						47.8	0.72	91.9
Tea, brewed						37.9	0.50	12.0
2σ$_{\bar{x}}$, counting error Tea						16.7	0.33	5.9
Tea, brewed						26.3	0.48	1.3
n Tea						12	12	6
Tea, brewed						7	7	11

See footnotes at end of table.

Table 2g. Radionuclides in imported foods, cocoa

Food type and treatment or condition	Collection site	Collecting district or field office	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (gK/kg)	^{90}Sr (pCi/kg)
Cocoa	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	140 ±51	18.00 ±1.10	94.00 ±6.60
Cocoa	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	163 ±46	19.13 ± .60	61.05 ±5.48
Cocoa	Bakersfield, Calif.	SAN—DO	2/13	ND	ND	144 ±43	16.11 ± .91	66.00 ±5.00
Cocoa	Atlanta, Ga.	ATL—FO	2/26	ND	ND	121 ±23	18.41 ± .96	59.00 ±4.00
Cocoa	Ft. Lauderdale. Fla.	ATL—FO	3/ 5	ND	ND	128 ±42	17.6 ± .94	63.60 ±3.90
Cocoa	Lafayette, La.	NOL—DO	3/12	ND	ND	124 ±41	17.70 ± .90	65.90 ±3.60
Cocoa	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	125 ±41	17.10 ± .90	58.20 ±3.70
Cocoa	N. Massapequa, N.Y.	NYK—DO	4/24	ND	ND	95 ±43	16.80 ± .90	70.30 ±5.00
Cocoa	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	ND	17.30 ± .90	72.70 ±4.90
Cocoa mix	New Britain, Conn.	BOS—FO	6/11	ND	ND	66 ±37	10.3 ± .70	36.70 ±2.90
Cocoa	Alliance, Nebr.	KAN—DO	6/20	ND	ND	148 ±44	16.50 ± .90	62.90 ±3.70
Cocoa	Beloit, Wis.	MIN—DO	7/10	ND	ND	147 ±44	17.60 ± .90	69.00 ±4.00
Average, $\bar{x}$						127.4	16.9	64.9
2 S$_{\bar{x}}$, among						16.4	1.3	7.5
2σ$_{\bar{x}}$, counting error						12.6	0.3	1.3
n						11	12	12

See footnotes at end of table.

Table 2h. Radionuclides in imported foods, cashew nuts

Food type and treatment or condition	Collection site	Collecting district or field office	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	K[c] (g K/kg)	^{90}Sr (pCi/kg)
Cashews	Anaheim, Calif.	LOS—DO	1/ 2	ND	ND	89 ±27	5.57 ±0.50	5.40 ±0.90
Cashews	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	65 ±24	6.42 ± .50	5.70 ± .98
Cashews	Bakersfield, Calif.	SAN—FO	2/13	ND	ND	141 ±27	6.52 ± .50	25.00 ±2.00
Cashews	Atlanta, Ga.	ATL—FO	2/26	ND	ND	61 ±25	5.72 ± .46	8.20 ±2.00
Cashews, canned	Ft. Lauderdale, Fla.	ATL—FO	3/ 5	ND	ND	72 ±42	5.41 ± .45	8.90 ±1.80
Cashews, canned	Lafayette, La.	NOL—DO	3/12	ND	ND	82 ±24	5.96 ± .45	5.30 ±1.00
Cashews	Jersey City, N.J.	NYK—DO	4/ 9	ND	ND	28 ±26	5.80 ± .50	4.00 ±1.00
Cashews	Plainview, N.Y.	NYK—DO	4/25	ND	ND	189 ±27	6.06 ± .47	25.20 ±2.10
Cashews	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	61 ±26	6.00 ± .50	4.80 ±1.20
Cashews	New Britain, Conn.	BOS—FO	6/11	ND	ND	36 ±25	5.93 ± .47	1.59 ± .70
Cashews	Alliance, Nebr.	KAN—DO	6/20	ND	ND	80 ±28	6.40 ± .50	3.96 ± .98
Cashews	Beloit, Wis.	MIN—DO	7/10	ND	ND	35 ±27	5.60 ± .50	5.50 ±1.00
Average, $\bar{x}$						78.3	5.95	8.63
2 S$_{\bar{x}}$, among						26.6	0.21	4.57
2σ$_{\bar{x}}$, counting error						8.0	0.14	0.40
n						12	12	12

[a] Country of origin is given only if known.

[b] See figure 1.

[c] The g K/kg levels of stable potassium in commodities are computed from the potassium-40 activity. Potassium-40 occurs in nature to the extent of 0.011 percent of total potassium

[d] 2S$_{\bar{x}}$ among $= 2\sqrt{S^2/n}$, "two standard deviations of the estimate of the mean, $\bar{x}$."

[e] 2σ$_{\bar{x}}$ counting error $= \frac{2\sqrt{\Sigma\,(\text{counting error})^2}}{n}$

[f] The specific activity (pCi/kg) of brewed coffee was normalized to the dry weight of the sample.

[g] The specific activity (pCi/kg) of brewed tea was normalized to the dry weight of the sample.

ative assumptions, the levels of cesium-137 and strontium-90 found in percolated coffee are well within Range I of the guides. In the case of tea, all brewed samples are within Range I and II of the guides for both cesium-137 and strontium-90.

All 12 samples of cocoa had strontium-90 levels within Range II of the guides, while cesium-137 fell within Range I. In the case of cashew nuts, all samples were within Range I for cesium-137 and only two samples showed levels of strontium-90 in Range II. In all cases where Range II levels were found in individual foods, corrections for their relative percentage

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Table 3. Radionuclides in total diet, market basket composites

Composite number[a]	Commodity type	Collection site	Collecting district office	Collection date (1973)	^{131}I (pCi/kg)	^{106}Ru (pCi/kg)	^{137}Cs (pCi/kg)	^{40}K (pCi/kg)	^{90}Sr (pCi/kg)
1	Dairy products	Carson City, Nev.	SAN—DO	10/30	ND	ND	ND	1.82 ±0.30	3.2 ±0.54
2	Meat, fish, poultry	Lake Charles, La.	NOL—DO	1/ 8	ND	ND	ND	2.45 ± .40	0.77 ± .72
3	Grain and cereal products	Odessa, Tex.	Dallas—DO	2/21	ND	ND	ND	1.76 ± .63	9.40 ±2.10
4	Potatoes	Lafayette, La.	NOL—DO	3/12	ND	ND	ND	5.09 ± .42	11.2 ±1.20
5	Leafy vegetables	Jersey City, N.J.	BAL—DO	4/ 9	ND	ND	ND	1.90 ± .50	4.80 ±1.60
6	Legume vegetables	Charleston, W. Va.	BAL—DO	5/ 7	ND	ND	ND	2.45 ± .42	6.35 ±1.02
7	Root vegetables	Rochester, N.Y.	Buffalo—DO	6/ 4	ND	ND	ND	2.44 ± .64	8.88 ±2.12
8	Garden fruits	Beloit, Wisc.	MIN—DO	7/10	ND	ND	ND	2.06 ± .30	4.00 ± .80

[a] See appendix A.

in the diet would yield a total diet well within Range I.

These findings are further supported by data reported for the eight total diet composites presented in table 3. No iodine-131, ruthenium-106, nor cesium-137 were found within detectable limits of the methods. The levels for strontium-90 were within Range I of the guides for all total diet composites. These data are indicative of the "dilution effect" on the radionuclide levels as a result of the normal preparation of foods usual to the family household.

Summary

As the agency responsible for the wholesomeness of the nation's food supply, the FDA has instituted a monitoring program for radionuclides in the nation's total diet and selected import food commodities.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides. Data derived from this program will continue to be evaluated and compared with the FRC Guidelines for radionuclides in foods as the reference point in any possible regulatory action that may be necessary.

Acknowledgement

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Total diet market basket

Commodity	Quantity		Equivalent weight (g)
I. Dairy products:			
Milk, fresh fluid	9 quarts	8 fluid ounces	
Evaporated milk		7 fluid ounces	
Nonfat dry milk		2 ounces	57
Ice cream	1 quart	6 fluid ounces	
Cottage cheese		6 ounces	170
Processed cheese (American)		4 ounces	114
Natural cheese		3 ounces	85
Butter		7 ounces	199
Margarine		10 ounces	284
Skim milk	1 pint	3 fluid ounces	
II. Meat, fish and poultry:			
Roast beef		14 ounces	398
Ground beef (chuck)		9 ounces	256
Pork chops	1 pound	1 ounce	483
Bacon		7 ounces	199
Chicken (one whole eviscerated fresh or frozen)	2 pounds	1 ounce	937
Fish fillet (fresh or frozen)		7 ounces	199
Tuna or salmon (canned)		4 ounces	114
Luncheon meat		12 ounces	341
Frankfurters		7 ounces	199
Liver, beef		4 ounces	114
Eggs, large		14 each	
Cured ham (not canned)		9 ounces	256
Round steak (beef)	1 pound	13 ounces	824
Veal, chops or cutlets		4 ounces	114
Lamb, roast		4 ounces	114
Raw shrimp (fresh or frozen)		2 ounces	57
III. Grain and cereal products:			
Flour, general purpose		8 ounces	227
Pancake mix		1 ounce	28
Corn flakes		5 ounces	142
Shredded wheat or wheat cereal		3 ounces	85
Rice flakes or puffed rice		2 ounces	57
Oatmeal		5 ounces	142
Rice		13 ounces	369
Macaroni		15 ounces	426
White bread, enriched	5 pounds	11 ounces	2 584
Whole wheat bread		3 ounces	85
Rolls (sweet, cinnamon, Bismarcks, etc.)		8 ounces	227
Snack item (pretzels, corn chips, crackers, etc.)		10 ounces	284
Cookies, plain (w/o nuts or chocolate)	1 pound	2 ounces	511
Buns, frankfurter or hamburger		7 ounces	199
Pie crust (fruit filling-IX)		7 ounces	199
Cake mix		5 ounces	142
Wheat cereal, uncooked		2 ounces	57
Corn (raw)		13 ounces	369
Corn (canned)		13 ounces	369
Corn (frozen)		13 ounces	369
IV. Potatoes:			
Potatoes, white			
(bake 1/2)	3 pounds	10 ounces	1 647
(boil 1/4)	1 pound	13 ounces	824
(fry 1/4)	1 pound	13 ounces	824
Potato chips		6 ounces	170
Frozen french fries		6 ounces	170
Sweet potatoes or yams (fresh)		1 ounce	28
Sweet potatoes or yams (canned)		1 ounce	28
V. Leafy vegetables:			
Spinach, collard or mustard greens (raw)		6 ounces	170
Spinach, collards or mustard greens (frozen)		6 ounces	170
Spinach, collards or mustard greens (canned)		6 ounces	170
Celery (raw)		5 ounces	142
Lettuce (raw)	1 pound	3 ounces	540
Cabbage (raw 1/2)		1.5 ounces	43
Cabbage (boil 1/2)		1.5 ounces	43
Broccoli (fresh)		2 ounces	57
Broccoli (frozen)		2 ounces	57
Asparagus (fresh)		5 ounces	142
Asparagus (frozen)		5 ounces	142
Asparagus (canned)		5 ounces	142
VI. Legume vegetables:			
Peas (raw)		10 ounces	284
Peas (canned)		10 ounces	284

Total diet market basket—continued

Commodity	Quantity		Equivalent weight (g)
VI. Legume vegetables:			
Peas (frozen)		10 ounces	284
Green beans (raw)		10 ounces	284
Green beans (canned)		10 ounces	284
Green beans (frozen)		10 ounces	284
Beans with pork (canned)	1 pound	3 ounces	540
Lima beans (frozen)		1 ounce	28
VII. Root vegetables:			
Carrots (raw)		10 ounces	284
Carrots (canned)		10 ounces	284
Onions, dry (raw 1/2)		5 ounces	142
Onions, dry (boil 1/2)		5 ounces	142
Beets without tops (raw)		4 ounces	114
Beets without tops (canned)		4 ounces	114
Green onions		3 ounces	85
VIII. Garden fruits:			
Green peppers (raw)		4 ounces	114
Tomatoes (fresh)		10 ounces	284
Tomatoes (canned)		7 ounces	199
Cucumbers (raw)		6 ounces	170
Catsup		3 ounces	85
Pickles		4 ounces	114
Vegetable soup (canned)	1 pound		454
Tomato soup (canned)		2 ounces	57
IX. Fruits:			
Fruit filling from pie			
Oranges (fresh)	1 pound	2 ounces	511
Citrus juice (frozen concentrate)		4 fluid ounces	
Bananas	1 pound	5 ounces	596
Raisins		1 ounce	28
Peaches (fresh)		6 ounces	170
Peaches (canned)		6 ounces	170
Apples (fresh)	1 pound	4 ounces	568
Strawberries (raw, fresh)		3 ounces	85
Strawberries (frozen)		3 ounces	85
Citrus juice (canned)		13 fluid ounces	
Citrus juice (fresh)		13 fluid ounces	
Prunes		1 ounce	28
Grapefruit		9 ounces	256
Fruit juice, noncitrus (canned)		9 fluid ounces	
Apricots (raw)		1 ounce	28
Apricots (canned)		1 ounce	28
Cherries (raw)		1 ounce	28
Cherries (canned)		1 ounce	28
Grapes (raw)		2 ounces	57
Pears (raw)		3 ounces	85
Pears (canned)		3 ounces	85
Pineapple (raw)		1 ounce	28
Pineapple (canned)		1 ounce	28
Rhubarb without tops (raw)		1 ounce	28
Watermelon (raw)	1 pound		454
Cantaloupe (raw)		4 ounces	114
Fruit cocktail		4 ounces	114
X. Oils, fats and shortening:			
Salad dressing-french		1 fluid ounce	
Salad dressing-mayonnaise		5 fluid ounces	
Salad dressing-salad		1 fluid ounce	
Shortening		12 ounces	341
Peanut butter		6 ounces	170
XI. Sugar and adjuncts:			
Sugar, white	1 pound	5 ounces	596
Jelly		2 ounces	57
Pudding mix		3 ounces	85
Syrup, blended		1 ounce	
Jam		1 ounce	28
Candy bars		7 ounces	199
Baking powder		1/2 ounce	14
Salt		3 ounces	85
Vinegar		2 ounces	
XII. Beverages:			
Tea leaves		1 ounce	28
Coffee, ground		6 ounces	170
Cocoa		2 ounces	57
Cola soft drink		25 ounces	
Noncola soft drink		36 ounces	
Coffee, instant		1 ounce	28
Drinking water		8.5 liters	

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[a] All weights indicated are raw or unprocessed weights. The actual weight of cooked or prepared food would be less in such items as meats and vegetables or fruits which are normally peeled and cooked before consumption.

Data

SECTION I. MILK AND FOOD

Milk Surveillance, May 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State Health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

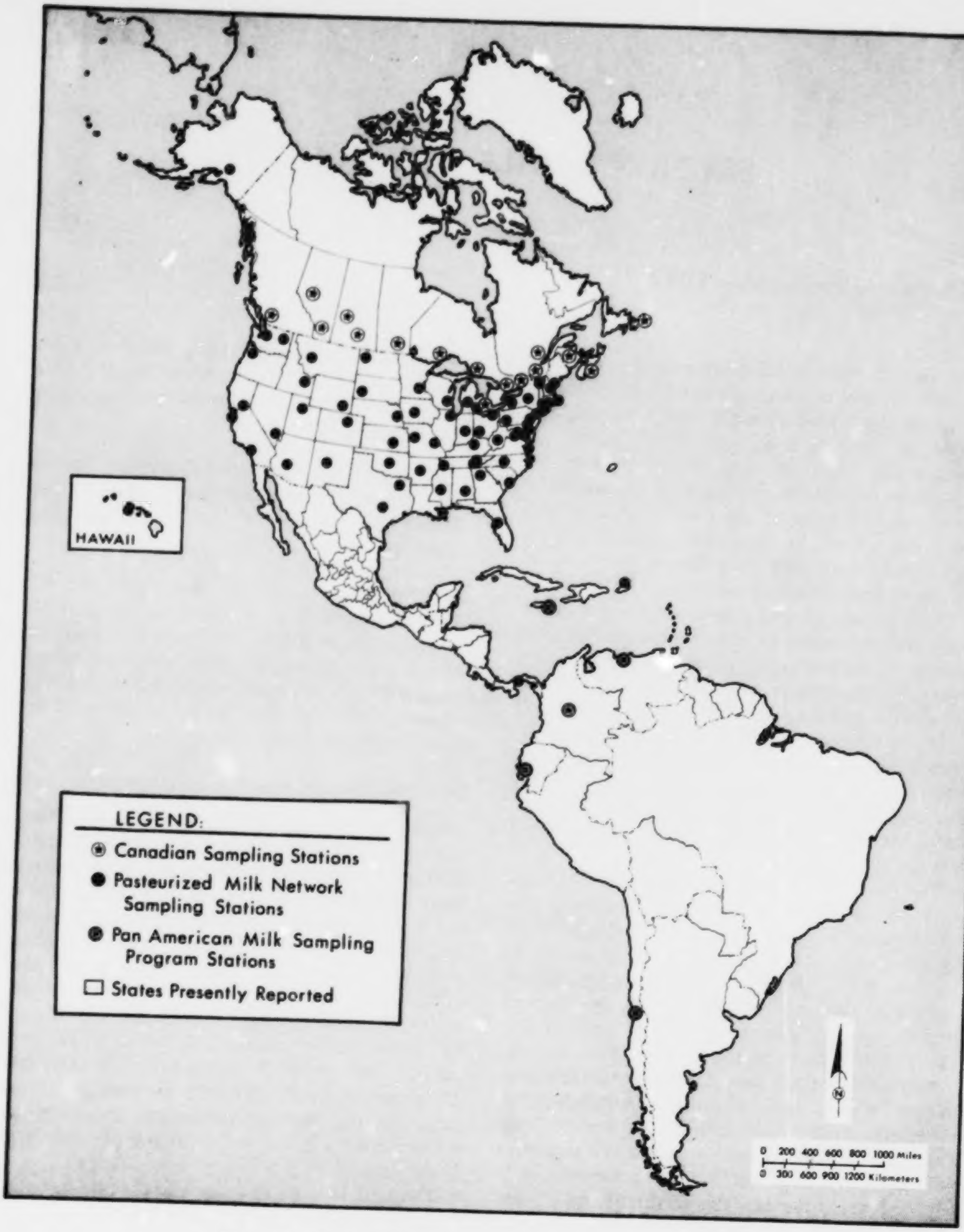
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
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Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131:	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137:	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89:	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90:	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports.* The relationship between the

Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	3	0	3
Alaska:	Palmer [c]	P	NS	4	NS	2
Ariz:	Phoenix [c]	P	NA	0	12	1
Ark:	Little Rock [c]	P	NA	13	13	2
Calif:	Los Angeles [c]	P	NA	0	0	0
	Sacramento [c]	P	NA	0	15	2
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	10	9	10	4
	Fresno	P	0	1	0	1
	Humboldt	P	4	2	0	0
	Los Angeles	P	0	1	0	2
	Mendocino	P	4	2	0	2
	Sacramento	P	2	1	0	2
	San Diego	P	1	1	0	1
	Santa Clara	P	0	1	0	2
	Shasta	P	2	2	0	2
	Sonoma	P	4	2	0	3
Colo:	Denver [c]	P	NA	3	0	0
	East	R	NS	NA	NS	23
	Northeast	R	NA	NA	0	4
	Northwest	R	NS	NA	NS	3
	South Central	R	NS	NS	NS	NS
	Southeast	R	NA	NA	0	0
	Southwest	R	NA	NA	0	0
	West	R	NA	NA	NS	0
Conn:	Hartford [c]	P	NA	4	0	1
	Central	P	NA		NA	
Del:	Wilmington [c]	P	NA	8	16	3
D.C:	Washington [c]	P	NA	4	13	1
Fla:	Tampa [c]	P	NA	4	29	26
	Central	R	4	5	24	27
	North	R	5	6	14	12
	Northeast	R	5	6	21	26
	Southeast	R	5	5	34	45
	Tampa Bay area	P	4	4	19	25
	West	R	9	8	11	20
Ga:	Atlanta [c]	P	NA	4	14	2
Hawaii:	Honolulu [c]	P	NA	0	0	0
Idaho:	Idaho Falls [c]	P	NA	4	0	0
Ill:	Chicago [c]	P	NA	5	0	0
Ind:	Indianapolis [c]	P	NA	5	11	4
	Central	P	6	5	0	4
	Northeast	P	7	6	15	10
	Northwest	P	7	7	10	7
	Southeast	P	6	6	10	7
	Southwest	P	7	7	20	6
Iowa:	Des Moines [c]	P	NA	4	0	0
	Des Moines	P	6	5	0 (2)	0
	Iowa City	R	5	5	0	0
	LeMars	R	NS	NS	NS	0
	Little Cedar	R	6	6	0	0
Kans:	Wichita [c]	P	NA	6	0	1
	Coffeyville	P	4	6	0	7
	Dodge City	P	2	4	NS	7
	Falls City, Nebr	R	4	5	NS	8
	Hays	P	5	6	NS	4
	Kansas City	P	7	5	NS	5
	Topeka	P	3	6	10	6
Ky:	Louisville [c]	P	NA	5	11	2
La:	New Orleans [c]	P	NA	4	17	4
Maine:	Portland [c]	P	NA	8	15	12
Md:	Baltimore [c]	P	NA	8	16	3
Mass:	Boston [c]	P	NA	8	11	5
Mich:	Detroit [c]	P	NA	6	12	3
	Grand Rapids [c]	P	NA	7	0	1
	Bay City	P	9	10	0	2
	Charlevoix	P	10	9	0	2
	Detroit	P	7	9	0	0
	Grand Rapids	P	10	13	0	5
	Lansing	P	10	11	0	3
	Marquette	P	11	13	0	6
	Monroe	P	10	13	0	1
	South Haven	P	10	14	0	2
Minn:	Minneapolis [c]	P	NA	7	0	1
	Bemidji	P	9	7	0	0
	Duluth	P	13	15	0	15
	Fergus Falls	P	4	5	0	0
	Little Falls	P	16	15	0	24
	Mankato	P	6	5	0	0
	Marshall	P	NS	3	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—Continued						
Minn:	Minneapolis	P	10	9	0	0
	Rochester	P	4	6	0	0
Miss:	Jackson [c]	P	NA	8	15	5
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	8	0	1
Mont:	Helena [c]	P	NA	0	0	0
Nebr:	Omaha [c]	P	NA	0	0	0
Nev:	Las Vegas [c]	P	NA	8	0	0
N.H:	Manchester [c]	P	NA	9	0	5
N.J:	Trenton [c]	P	NA	4	0	1
N. Mex:	Albuquerque [c]	P	NA	0	0	0
N.Y.	Buffalo [c]	P	NA	5	0	0
	New York City [c]	P	NA	4	0	2
	Syracuse [c]	P	NA	6	14	2
	Albany	P	4	4	0	0
	Buffalo	P	6	5	0	0
	Massena	P	6	7	0	10
	New York City	P	7	6	0	0
	Syracuse	P	5	4	0	0
N.C:	Charlotte [c]	P	NA	9	11	5
	Asheville	P	0		0	
	Charlotte	P	0		13	
	Lexington	P	0		0	
	New Bern	P	NS		NS	
	Raleigh	P	0		0	
	Wilkesboro	P	0		0	
N. Dak:	Minot [c]	P	NA	6	0	0
Ohio:	Cincinnati [c]	P	NA	6	12	3
	Cleveland [c]	P	NA	7	0	2
Okla:	Oklahoma City [c]	P	NA	2	0	0
Oreg:	Portland [c]	P	NA	3	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	0	2
	Pittsburgh [c]	P	NA	10	12	3
	Dauphin	P	4	5	0	0
	Erie	P	7	7	0	1
	Philadelphia	P	5	5	0	0
	Pittsburgh	P	7	6	0	0
R.I:	Providence [c]	P	NA	4	12	5
S.C:	Charleston [c]	P	NA	5	20	9
	Anderson-01	R	NS	7	NS	0
	Anderson-02	R	NS	6	NS	0
	Chapin	R	NS	7	NS	8
	Clemson	R	NS	8	NS	8
	Columbia	R	NS	7	NS	10
	Fairfield	R	NS	6	NS	11
	Hartsville-02	R	NS	6	NS	9
	Hartsville-03	R	11	13	15	13
	Lee County	R	7	7	14	9
	Oconee County	R	NS	7	NS	5
	Pickens	R	NS	7	NS	9
	Williston	R	7	7	14	15
	Winnsboro	R	NS	6	NS	15
	York-01	R	7	7	5	5
	York-02	R	5	5	0	0
S. Dak:	Rapid City [c]	P	NA	8	0	1
Tenn:	Chattanooga [c]	P	NA	6	12	3
	Knoxville	P	NA	0	0	2
	Memphis [c]	P	NA	6	11	3
	Chattanooga	P	9	8	0	2
	Clifton	R	12	9	0	1
	Fayetteville	R	8	9	16	3
	Kingston	R	11	9	20	2
	Knoxville	P	9	7	13	3
	Lawrenceburg	R	4	5	0	0
	Nashville	P	8	6	0	0
	Pulaski	R	5	6	0	0
	Sequoyah	R	NS	9	NS	0
Tex:	Austin [c]	P	NA	0	0	0
	Dallas [c]	P	NA	3	0	0
Utah:	Salt Lake City [c]	P	NA	1	0	0
Vt:	Burlington [c]	P	NA	5	0	3
Va:	Norfolk [c]	P	NA	6	0	1

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for May 1974 and 12-month period, June 1973 through May 1974—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Seattle [c]	P	NA	0	15	1
	Spokane [c]	P	NA	4	0	0
	Benton County	R	0	0	0	0
	Franklin County	R	NS	1	NS	0
	Longview	R	6	5	11	8
	Sandpoint, Idaho	R	6	5	0	1
	Skagit County	R	11	4	15	1
W. Va:	Charleston [c]	P	NA	8	0	1
Wisc:	Milwaukee [c]	P	NA	3	0	1
Wyo:	Laramie [c]	P	NA	0	0	1
CANADA:						
Alberta:	Calgary	P	NA		0	5
	Edmonton	P	NA		0	9
British Columbia:						
	Vancouver	P	NA		14	11
Manitoba:						
	Winnipeg	P	NA		0	9
New Brunswick:						
	Moncton	P	NA		0	8
Newfoundland:						
	St. John's	P	NA		0	12
Nova Scotia:						
	Halifax	P	NA		0	7
Ontario:	Ottawa	P	NA		0	5
	Sault Ste. Marie	P	NA		0	13
	Thunder Bay	P	NA		0	9
	Toronto	P	NA		0	5
	Windsor	P	NA		0	5
Quebec:	Montreal	P	NA		0	5
	Quebec	P	NA		NA	NA
Saskatchewan:						
	Regina	P	NA		0	4
	Saskatoon	P	NA		0	5
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal [c]	P	NA	0	0	0
Chile:	Santiago	P	0	0	0	1
Colombia:	Bogota	P	3	1	0	0
Ecuador:	Guayaquil	P	0	1	0	0
Jamaica:	Mandeville	P	NS		NS	
Puerto Rico:						
	San Juan [c]	P	NA	3	11	2
Venezuela:						
	Caracas	P	0	0	0	0
PMN network average [d]			NA	5	5	2

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[d] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for May 1974 and the 12-month period, June 1973 to May 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for May 1974 were below the respective practical reporting levels, except for strontium-89 at Coffeyville, Kans: 10 pCi/liter and Topeka, Kans: 6 pCi/liter.

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for North Carolina for January through April 1974.

Strontium-90 monthly averages ranged from 0 to 16 pCi/liter in the United States for May 1974 and the highest 12-month average was 15 pCi/liter (Little Falls, and Duluth, Minn.) representing 7.5 percent of the Federal Radiation

Table 3. Concentrations of radionuclides in North Carolina milk,[a] January–April 1974

Location in North Carolina	Type of sample	Radionuclide concentration (pCi/liter)		
		Strontium-90	Iodine-131	Cesium-137
Asheville:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	NA	NA
April		([b])	([b])	([b])
Charlotte:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	35	([b])
April		([b])	([b])	([b])
Lexington:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	NA	NA
April		([b])	([b])	([b])
New Bern:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	NA	NA
April		([b])	([b])	([b])
Raleigh:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	NA	NA
April		([b])	([b])	([b])
Wilkesboro:	P			
January		([b])	NA	NA
February		([b])	NA	NA
March		([b])	([b])	([b])
April		([b])	NA	NA

[a] Strontium-89 and barium-140 were all below the minimum detectable limit.

[b] Below minimum detectable limit.

NA, no analysis.

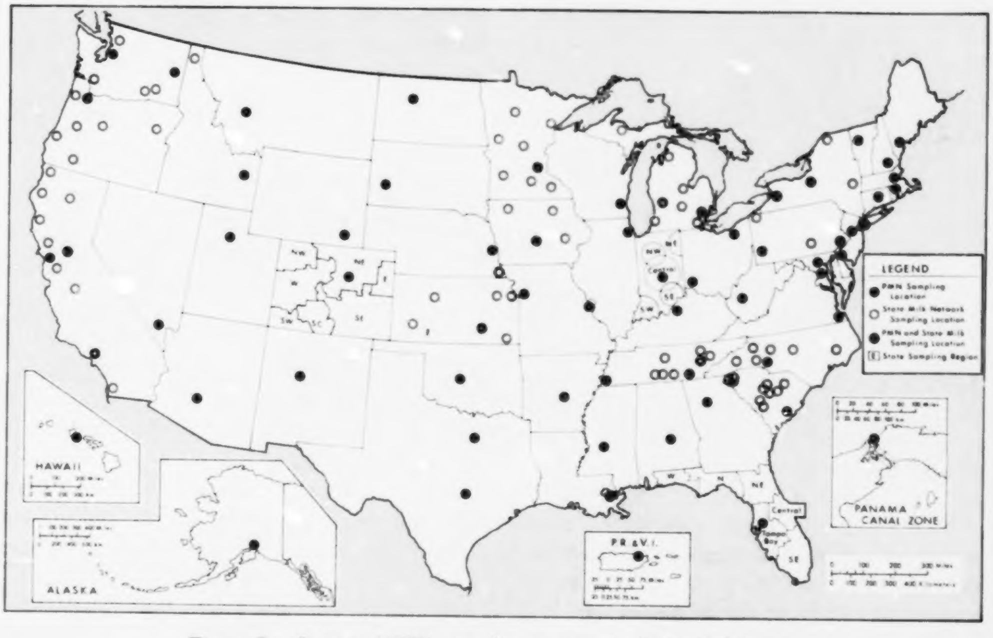
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
E State Sampling Region
HAWAII
ALASKA
PR & V.I.
PANAMA CANAL ZONE
Central
SE
NE
NW
W
SW
SC
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 2. State and PMN sampling stations in the United States

Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 34 pCi/liter in the United States for May 1974, and the highest 12-month average was 45 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Radiation Protection Branch
Division of Facility Services
North Carolina Department of Human Resources

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

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(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, HASL	1972	December 1973

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Radioactivity in Washington Surface Water[1] July 1971–June 1972

Washington State Department of Social and Health Services

Radioanalysis of surface water samples collected through the State is one of the major functions of the Washington State Department of Social and Health Services radiation surveillance program. Collection of these samples is performed by numerous cooperating agencies, including local water departments, county health districts, and other State agencies. Figure 1 shows the surface water sampling locations and code numbers.

All water is collected in 1-gallon cubitainers by grab sampling and is mailed to the State radiation laboratory in Seattle for analysis. A description of the analytical procedures used was presented in the August 1973 issue of *Radiation Data and Reports.* Some special analyses are performed by the National Environmental Research Center—Las Vegas (NERC-LV).

Analyses results of Columbia River samples are reported separately because of the unique isotopes present (table 1). The data reflect the more detailed laboratory analysis that Columbia River samples receive in order to document the significant isotopes present.

Concentrations of radioactivity in the Columbia River dropped below detectability limits following the shutdown on January 29, 1971,

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[1] Summarized from "Environmental Radiation Surveillance in Washington State, Eleventh Annual Report, July 1971–June 1972."

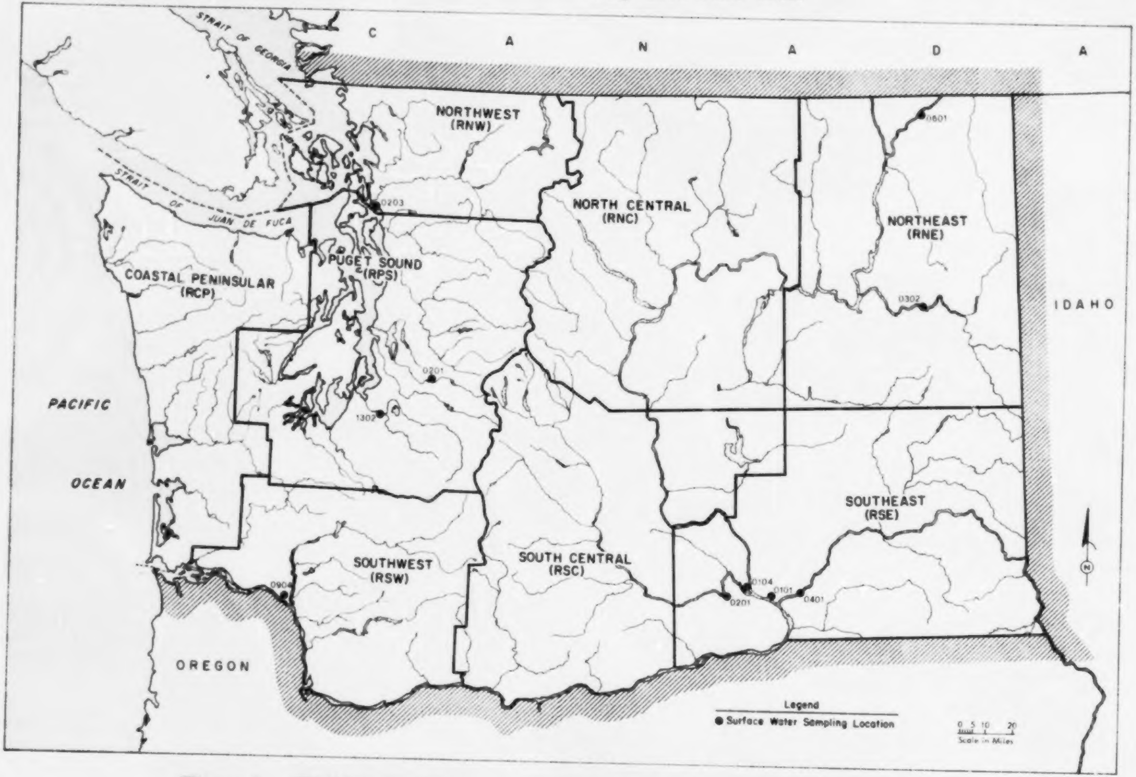
C A N A D A
STRAIT OF GEORGIA
STRAIT OF JUAN DE FUCA
NORTHWEST (RNW)
NORTH CENTRAL (RNC)
NORTHEAST (RNE)
COASTAL PENINSULAR (RCP)
PUGET SOUND (RPS)
SOUTHWEST (RSW)
SOUTH CENTRAL (RSC)
SOUTHEAST (RSE)
PACIFIC
OCEAN
OREGON
IDAHO
0203
0601
0302
0201
1302
0904
0104
0101
0201
0401
N
Legend
● Surface Water Sampling Location
0 5 10 20
Scale in Miles

Figure 1. Washington surface water sampling locations with code numbers

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Table 1. Monthly average radioactivity in Columbia River water, July 1971–June 1972

Sampling media	Radioactivity concentration (pCi/liter)											
	1971						1972					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code No. RNE 0601)												
Beta-particle:												
Tritium[a][b]	700			1 200						870		
Richland (code no. RSE 0104)												
Beta-particle:												
Suspended[c]	<1	1	<1	1	1	1	<1	2	3	<1	2	4
Dissolved[c]	3	4	3	4	3	3	3	3	4	2	3	3
Total[c]	3	5	3	5	4	4	3	5	7	2	5	7
Phosphorus-32[b]	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA	NA	NA
Gamma-ray[b]												
Chromium-51	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zinc-65	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Scandium-46	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pasco (code no. RSE 0101)												
Beta-particle:												
Suspended[c]	<1	<1	<1	<1	3	2	<1	<1	<1	2	<1	<1
Dissolved[c]	2	4	2	2	4	3	2	2	2	4	2	2
Total[c]	2	4	2	2	7	5	2	2	2	6	2	2
Phosphorus-32[b]	<1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tritium[a][b]	800			600			750			930		
Gamma-ray:[b]												
Chromium-51	<50	<50	<50	<50	<50	<50	NA	<50	<50	<50	<50	<50
Zinc-65	<10	<10	<10	<10	<10	<10	NA	<10	<10	<10	<10	<10
Scandium-46	<5	<5	<5	<5	<5	<5	NA	<5	<5	<5	<5	<5
Longview (code no. RSW 0904)												
Beta-particle:												
Suspended[c]	NS	NS	<1	<1	NS	NS	NS	NS	2	<1	<1	<1
Dissolved[c]	NS	NS	2	2	NS	NS	NS	NS	3	2	2	2
Total[c]			2	2					5	2	2	2
Phosphorus-32[b]	NS	NS	NA	NA	NS	NS	NS	NS	NA	NA	NA	NA
Gamma-ray:[b]												
Chromium-51	NS	NS	<50	<50	NS	NS	NS	NS	<50	<50	<50	<50
Zinc-65	NS	NS	<10	<10	NS	NS	NS	NS	<10	<10	<10	<10
Scandium-46	NS	NS	<5	<5	NS	NS	NS	NS	<5	<5	<5	<5

[a] Analyses performed by the U.S. Environmental Protection Agency, National Environmental Research Center-Las Vegas.

[b] Results extrapolated to date of collection.

[c] Strontium-yttrium calibration standard. Gross beta results >10 pCi/liter extrapolated to date of collection. All other gross beta results as of date of count (1–20 days after collection).

NS, no sample.

NA, no analysis.

of the KE and the N reactors at Hanford. The KE reactor was the last of eight original plutonium producing reactors. These eight reactors used single pass cooling systems for the reactor core and were the major sources of radioactivity entering the Columbia River. The N reactor was designed for both plutonium and electrical power production. It uses a double loop cooling system so that river water used for cooling does not enter the reactor core. Its contribution of radioactivity to the river in comparison with the reactors using single pass cooling is negligible.

This was confirmed in July 1971 when the N reactor was reactivated; no detectable change was observed in the radioactivity levels of the river. Although the tremendous flow of the Columbia tends to mask any effect of the reactor, its mode of operation is a significant improvement over the older reactors. The N reactor (800 MWe) was the first of the large scale nuclear power generating stations when it reached full design power in 1966. In September 1971, it reached a 15 billion KWh milestone, being the first single-reactor power station in the world to reach that goal.

Monthly averages of monitoring data from the Columbia River at Richland have been plotted to show the fluctuating concentrations encountered for the period 1964 through June 1972. Figures 2–5 show phosphorus-32, scandium-46, chromium-51, and zinc-65 concentrations, respectively.

Surface waters, other than the Columbia River are sampled to monitor the combined effect of background and of atmospheric fall-

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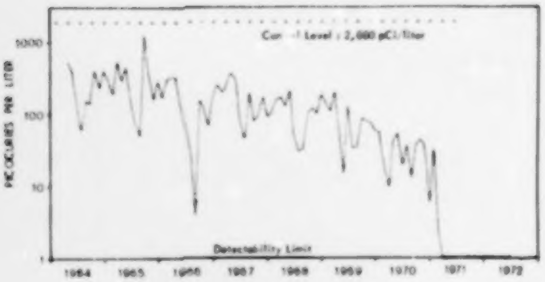

Figure 2. Phosphorus-32 monthly averages in Columbia river water, Richland, April 1964–June 1972

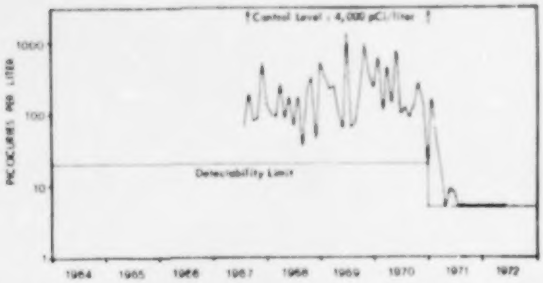

Figure 3. Scandium-46 monthly averages in Columbia river water, Richland, July 1967–June 1972

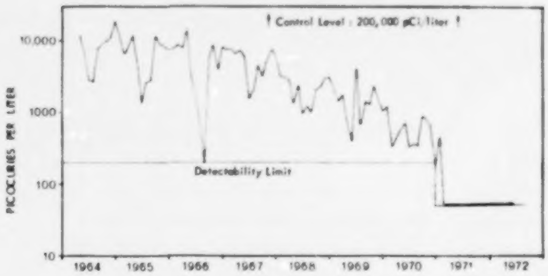

Figure 4. Chromium-51 monthly averages in Columbia river water, Richland, April 1964–June 1972

out (table 2). Figure 6 shows annual average and maximum gross beta activity in surface water samples for the period 1963 through 1972. The 1967 maximum of 26 pCi/liter on the plotted maximum values occurred in a Snake River sample resulting from fallout from the Chinese nuclear detonation of December 27, 1966. Other maximum values on the

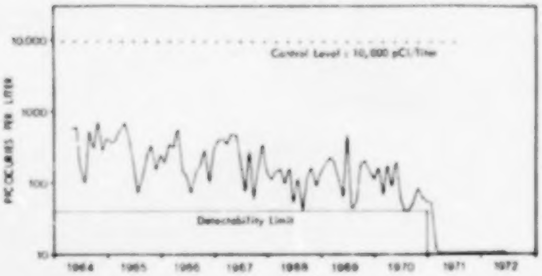

Figure 5. Zinc-65 monthly averages in Columbia river water, Richland, April 1964–June 1972

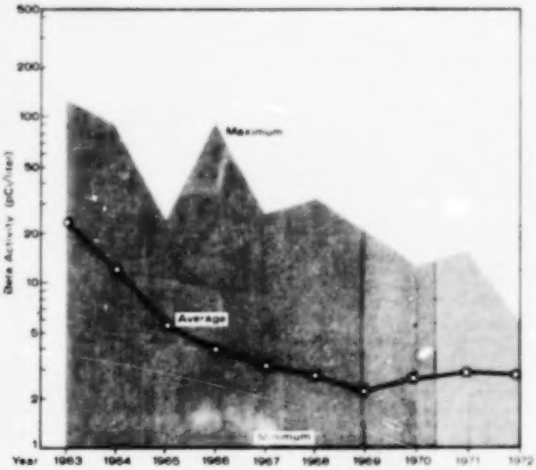

Figure 6. Average, maximum, and minimum beta radioactivity in surface waters, (excluding the Columbia river) 1963–1972

plot are associated with high turbidity samples.

Table 3 presents the individual sample results from the tritium analyses performed by the National Environmental Research Center—Las Vegas (NERC-LV).

Only three samples of salt water were collected and analyzed during this period. Laboratory efforts in this area have been directed toward developing capability for analyzing salt water for strontium-90. Past analyses have consisted of a gamma scan and a gross beta count. The data achieved by this method was judged practically useless: 1) the gamma scan of a 2 liter sample yielded no detectable results

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Table 2. Beta radioactivity[a] in Washington surface water (except for Columbia River) July 1971–June 1972

Location and type of analysis	Radioactivity concentration (pCi/liter)											
	1971						1972					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Cedar River (PS 0201)												
Landsberg:												
Suspended	<1	<1	<1	NS	<1	<1	1	<1	<1	<1	<1	<1
Dissolved	1	<1	<1		<1	<1	2	<1	5	<1	<1	<1
Puyallup River (PS 1302)												
Puyallup:												
Suspended	<1	4	<1	NS	NS	2	<1	<1	1	2	<1	1
Dissolved	2	2	2			2	1	2	<1	4	1	1
Skagit River (NW 0203)												
Conway:												
Suspended	<1	<1	<1	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved	2	2	1									
Snake River (SE 0401)												
Ice Harbor Dam:												
Suspended	NS	NS	NS	NS	NS	NS	NS	<1	2	NS	NS	NS
Dissolved								4	3			
Spokane River (NE 0302)												
Long Lake Dam:												
Suspended	<1	<1	<1	NS	NS	<1	<1	1	<1	<1	<1	<1
Dissolved	2	2	2			2	2	2	2	2	2	1
Yakima River (SE 0201)												
Kiona:												
Suspended	<1	<1	<1	NS	NS	<1	<1	<1	NS	1	2	1
Dissolved	3	4	4			3	2	2		1	2	2

[a] Strontium-yttrium calibration standard. Gross beta results <10 pCi/liter extrapolated to date at collection. All other gross beta results as of date of count (1–20 days after collection).

NS, no sample.

Table 3. Tritium[a] in Columbia River water, July 1971–June 1972

Sampling location	Collection date	Concentration (pCi/liter)
Northport	7/16/71	700
	10/ 5/71	1200
	4/26/72	870
Pasco	7/ 2/71	800
	10/ 6/71	600
	1/ 7/72	750
	4/ 5/72	930

[a] Analysis performed by National Environmental Research Center—Las Vegas (NERC-LV).

(other than natural potassium-40) because the concentrations present were far below the systems' detectability limits; 2) the gross beta data (either by a mixed fission product separation method or by a total gross beta method) were judged too ambiguous for use as a long-term baseline reference.

Another difficulty is the huge volume of salt water available for dilution and exchange, thus necessitating an extensive program of grab sampling to monitor average concentrations and trends. Therefore, future sampling of salt water will be restricted to approved reactor sites or to other specialized local situations.

The three salt water samples analyzed for strontium-90 yielded results of: <0.5, 0.5, and 1.8 pCi/liter.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
July 1970–June 1971	August 1973

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas	1972	August 1974
Krypton-85 in air	July 1970–1972	March 1974
Mexican air monitoring program	July–December 1973	May 1974

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1. ERAMS Gross Radioactivity and Deposition Component May 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated (figure 1) to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage. The component consists of 74 sampling stations, 55 of which are on standby status and can be activated when the need arises. The remaining 19 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples, which are collected concurrently at the air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A com-

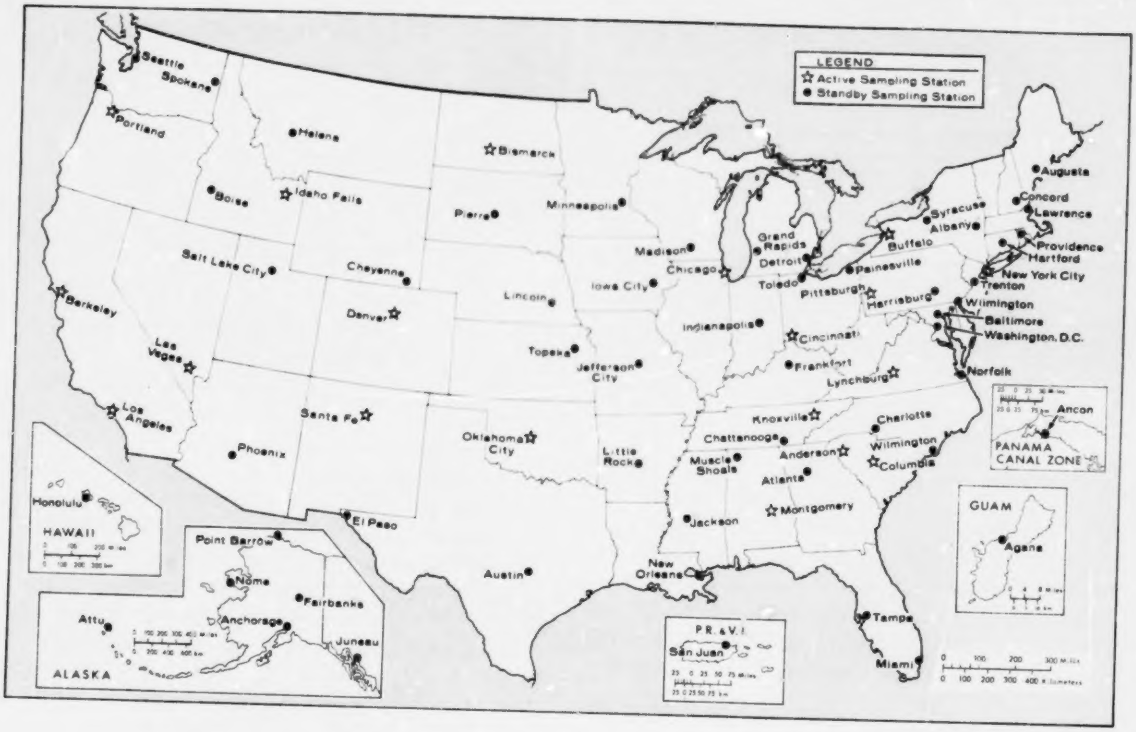
LEGEND
☆ Active Sampling Station
● Standby Sampling Station
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Idaho Falls
Pierre
Minneapolis
Salt Lake City
Cheyenne
Berkeley
Denver
Lincoln
Las Vegas
Topeka
Los Angeles
Santa Fe
Oklahoma City
Phoenix
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
Madison
Iowa City
Chicago
Grand Rapids
Detroit
Toledo
Jefferson City
Indianapolis
Cincinnati
Frankfort
Little Rock
Muscle Shoals
Chattanooga
Knoxville
Anderson
Atlanta
Montgomery
Jackson
New Orleans
Augusta
Concord
Lawrence
Syracuse
Albany
Buffalo
Providence
Hartford
Painesville
New York City
Trenton
Pittsburgh
Harrisburg
Wilmington
Baltimore
Washington, D.C.
Norfolk
Lynchburg
Charlotte
Wilmington
Columbia
Tampa
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling locations

pilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during May 1974.

Table 1. Gross beta radioactivity in surface air and precipitation, May 1974

Station location [a]		Number of samples	Gross beta radioactivity (pCi/m^3)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average [b]	Maximum	Minimum	Average [b]	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	9	1	0	1	0.34	0.08	0.19	50	0.36
Calif:	Berkeley	9	0	0	0	.16	.07	.12		
	Los Angeles	9	1	0	1	.25	.14	.19		
Colo:	Denver	9	2	1	1	.55	.22	.38	1	.11
Idaho:	Idaho Falls	9				.42	.14	.29	22	.67
Ill:	Chicago	5	4	1	2	.26	.06	.16		
Ind:	Indianapolis [e]	7	0	0	0	.26	.07	.18		
Nev:	Las Vegas	9	1	1	1	.39	.23	.31		
N.Mex:	Santa Fe	2	1	1	1	.30	.28	.29	14	.24
N.Y:	Buffalo	9	1	0	0	.34	.11	.20	2	.04
	New York City	(d)								
N.Dak:	Bismarck	9	2	0	1	.20	.05	.14	100	1.65
Ohio:	Columbus [c]	2	1	1	1	.29	.20	.24		
Okla:	Oklahoma City	0								
Oreg:	Portland	14	0	0	0	.27	.02	.10	44	.33
Pa:	Harrisburg [f]	13	1	0	1	.36	.12	.21		
S.C:	Anderson	(d)								
	Columbia	9	1	0	1	.34	.16	.23	46	.39
Tenn:	Knoxville	(d)								
Va:	Lynchburg	(d)								
Network summary		124	4	0	1	0.55	0.02	0.22	35	0.47

[a] The remaining stations are on standby status.
[b] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
[c] Standby station operated continuously at the request of the State.
[d] Station to be established.
[e] Station to be relocated to Cincinnati.
[f] Station to be relocated to Pittsburgh.

2. Air Surveillance Network, May 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

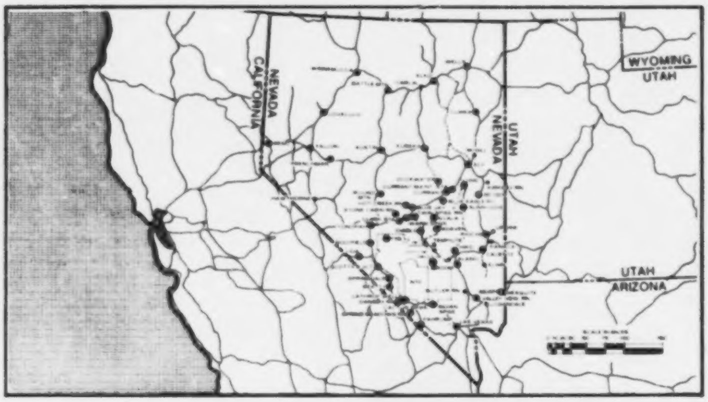
NEVADA
CALIFORNIA
UTAH
NEVADA
WYOMING
UTAH
UTAH
ARIZONA

Figure 2. NERC-LV Air Surveillance Network Stations in Nevada

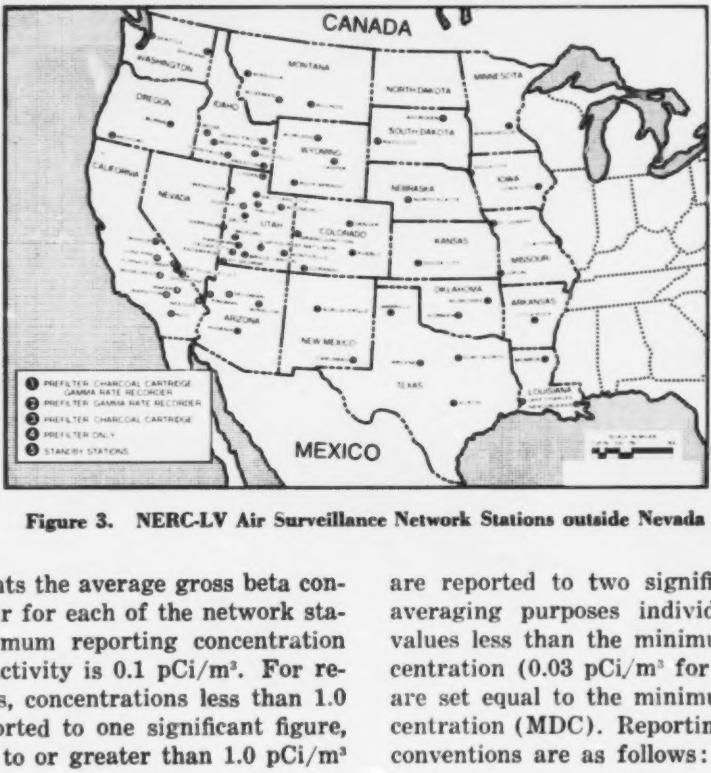
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MEXICO
1 PREFILTER, CHARCOAL CARTRIDGE GAMMA RATE RECORDER
2 PREFILTER, GAMMA RATE RECORDER
3 PREFILTER, CHARCOAL CARTRIDGE
4 PREFILTER ONLY
5 STANDBY STATIONS

Figure 3. NERC-LV Air Surveillance Network Stations outside Nevada

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to one significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to two significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (0.03 pCi/m^3 for a 700 m^3 sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are as follows:

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	<0.1	<0.1
$\geqq 0.05$ <0.15	0.1	<0.1
$\geqq 0.15$	As calculated and rounded	$<$ calculated MDC

As shown by table 2, the highest gross beta concentrations at continuously operated stations within the network were 2.0 pCi/m^3 at Bishop, Calif, 1.8 pCi/m^3 at Baker, Calif, and 1.5 pCi/m^3 at Currant Ranch, Nev.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-106 and cerium-141 were identified on filters collected throughout the network. The highest concentrations of these radionuclides, respectively, were 0.76 pCi/m^3, 1.1 pCi/m^3, and 1.0 pCi/m^3 in a sample collected at Bishop, Calif., on May 17. These radionuclides are attributed to seasonal variations in world fallout. No radionuclides were identified by gamma spectrometry on any charcoal cartridge during May 1974.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, May 1974

Sampling location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	14	1.0	0.4	0.6
	Seligman	14	.8	.2	.5
Calif:	Baker	14	1.8	<.1	.7
	Barstow	14	1.1	.2	.5
	Bishop	14	2.0	.4	.7
	Death Valley Junction	11	.9	.4	.6
	Furnace Creek	14	1.0	.4	.6
	Lone Pine	12	.8	.3	.4
	Needles	6	.9	.5	.6
	Ridgecrest	14	.9	.3	.5
	Shoshone	14	.7	.1	.5
Nev:	Alamo	14	.9	<.1	.5
	Austin	8	.6	.2	.3
	Beatty	14	.9	.3	.5
	Blue Eagle Ranch (Currant)	14	1.5	.2	.7
	Blue Jay	14	1.2	.3	.5
	Caliente	12	.7	.3	.5
	Currant Ranch	14	1.2	.2	.5
	Diablo	14	1.1	.3	.5
	Duckwater	14	.9	.1	.4
	Ely	14	1.0	<.1	.4
	Eureka	14	1.2	.2	.6
	Fallini's Twin Springs Ranch	13	1.3	.3	.6
	Goldfield	14	1.1	.2	.4
	Groom Lake	14	.7	<.1	.5
	Hiko	14	.9	<.1	.5
	Indian Springs	14	.5	.2	.4
	Las Vegas	19	.8	.1	.6
	Lathrop Wells	13	.7	.3	.5
	Lida	14	1.0	.2	.5
	Lund	12	.8	.2	.5
	Mesquite	14	.6	.3	.4
	Nyala	14	1.3	.3	.6
	Pahrump	14	.7	.1	.5
	Pioche	14	1.2	<.1	.5
	Round Mountain	14	1.3	.3	.5
	Scotty's Junction	13	1.1	.4	.6
	Stone Cabin Ranch	14	1.1	.1	.4
	Sunnyside	14	.8	<.1	.4
	Tonopah	14	1.2	.3	.5
	Tonopah Test Range	9	1.1	.3	.5
	Warm Springs	6	.8	.2	.5
	Warm Springs Ranch	15	.8	.2	.5
Utah:	Cedar City	3	.6	4	.5
	Delta	14	1.0	.2	.5
	Garrison	14	.8	.3	.6
	Milford	13	.9	<.1	.5
	St. George	13	1.2	.3	.6

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[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported a <0.1.

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3. Canadian Air and Precipitation Monitoring Program,[3] May 1974

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for May 1974 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, May 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.15	0.08	0.12	11.2	0.6
Coral Harbour	4	.12	.08	.12	136.9	.7
Edmonton	4	.19	.14	.17	144.6	8.1
Ft. Churchill	NS				87.6	1.1
Fredericton	4	.16	.07	.12	30.5	2.4
Goose Bay	4	.07	.04	.06	69.3	2.7
Halifax	4	.10	.04	.07	75.7	7.8
Inuvik	4	.14	.07	.11	358.9	.9
Montreal	4	.11	.03	.07	69.8	7.3
Moosonee	4	.19	.04	.12	94.1	8.1
Ottawa	4	.14	.04	.09	80.5	9.8
Quebec	4	.15	.07	.11	36.9	26.5
Regina	4	.15	.06	.11	82.1	7.7
Resolute	4	.13	.07	.10	49.0	.9
St. John's, Nfld	2	.13	.08	.11	58.0	6.3
Saskatoon	4	.13	.07	.10	67.0	7.0
Sault Ste. Marie	4	.22	.08	.15	91.7	4.9
Thunder Bay	4	.19	.06	.13	102.4	10.4
Toronto	NS				50.6	7.9
Vancouver	4	.13	.06	.10	11.7	1.4
Whitehorse	4	.14	.05	.10	148.6	5.7
Windsor	NS				57.8	4.7
Winnipeg	4	.10	.10	.14	38.9	6.1
Yellowknife	4	.12	.05	.09	121.7	3.5
Network summary	82	0.22	0.03	0.11	86.5	5.9

NS, no sample.

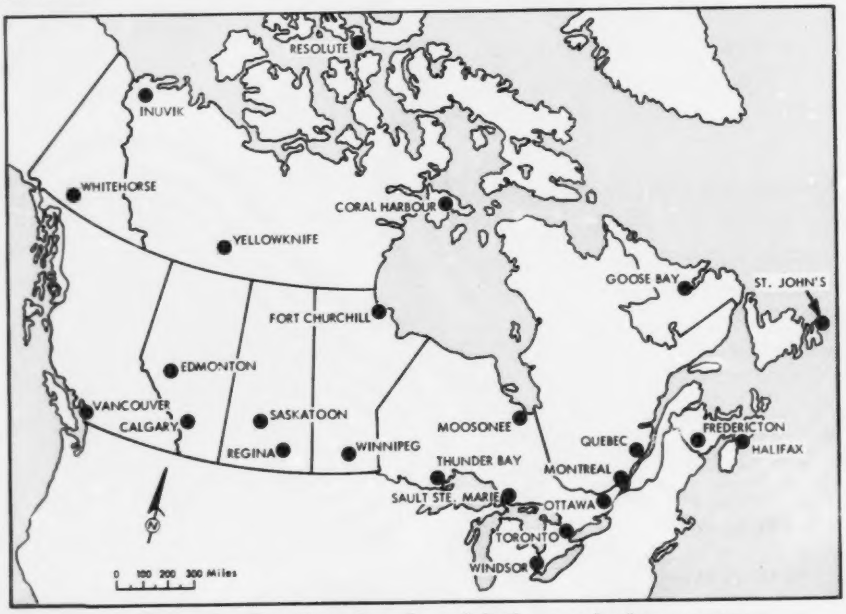
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air and precipitation monitoring program

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

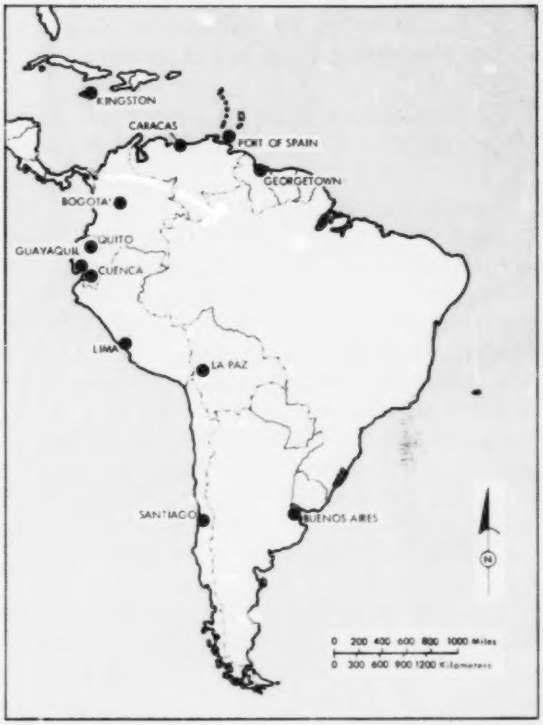

Figure 5. Pan American Air Sampling stations

4. Pan American Air Sampling Program May 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The May 1974 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, May 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	30	0.04	0.00	0.01
Colombia:	Bogota	19	.02	.00	.00
Ecuador:	Cuenca	7	.01	.00	.00
	Guayaquil	19	.03	.00	.01
	Quito	13	.01	.00	.00
Guyana:	Georgetown	2	.15	.11	.13
Jamaica:	Kingston	0			
Peru:	Lima	21	.02	.01	.01
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	2	.15	.03	.08
Pan American summary		113	0.15	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.00 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

5. California Air Sampling Program
May 1974

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

One of the objectives of the program is to evaluate the possibility that fixed effluent sources contribute to particulate activity in the air. Consequently, data from continuous air samplers placed in proximity to nuclear facilities are compared with those from similar equipment in nearby communities and at several "background" stations.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health. The filters are analyzed for

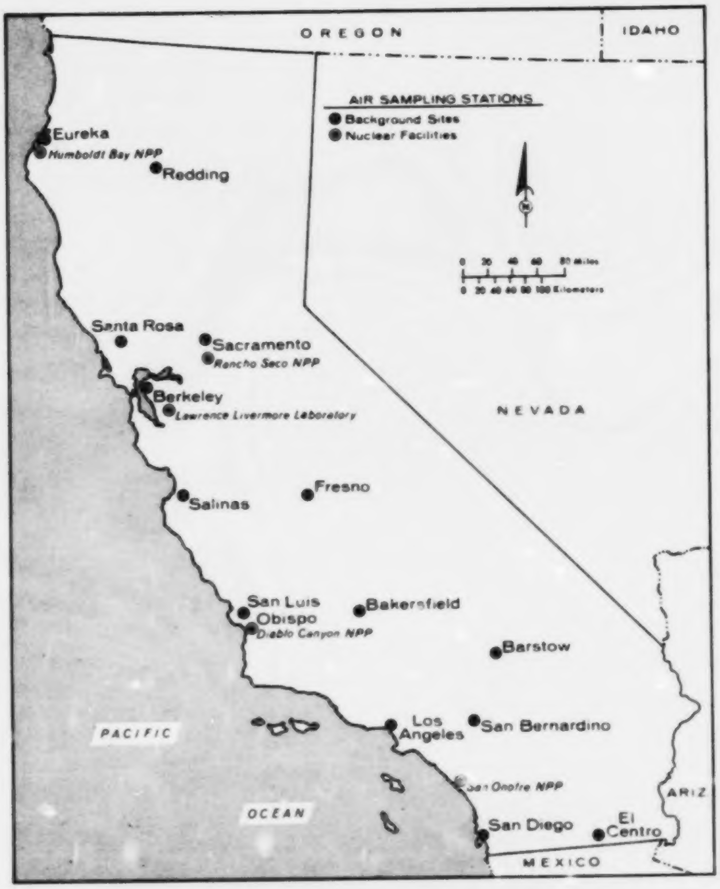
OREGON
IDAHO
AIR SAMPLING STATIONS
● Background Sites
● Nuclear Facilities
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Humboldt Bay NPP
Redding
Santa Rosa
Sacramento
Rancho Seco NPP
Berkeley
Lawrence Livermore Laboratory
NEVADA
Salinas
Fresno
San Luis Obispo
Bakersfield
Diablo Canyon NPP
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
San Onofre NPP
ARIZ
San Diego
El Centro
MEXICO

Figure 6. California air sampling program stations

gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. The monthly sample results are presented quarterly. Table 5 presents the gross beta radioactivity in air for May 1974.

Table 5. Gross beta radioactivity in California air, May 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	20	1.38	0.26	0.69
Barstow	30	1.22	.20	.69
Berkeley	30	.57	.00	.29
Diablo Canyon Nuclear Power Plant	8	.29	.14	.23
El Centro	21	1.58	.25	.69
Eureka	20	.52	.08	.22
Fresno	21	1.03	.18	.53
Humboldt Bay Nuclear Power Plant	14	.37	.10	.24
Livermore	22	.69	.07	.35
Los Angeles	21	.65	.14	.35
Rancho Seco Nuclear Power Plant	13	.65	.24	.43
Redding	20	1.81	.30	.92
Sacramento	22	.47	.14	.28
Salinas	22	.48	.11	.26
San Bernardino	19	.76	.25	.46
San Diego	22	.90	.00	.35
San Luis Obispo	22	.60	.00	.30
San Onofro Nuclear Generating Station	4	.37	.21	.28
Summary	351	1.81	0.00	0.42

6. ERAMS Plutonium and Uranium in Air Component October–December 1973

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973 was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Plutonium and Uranium in Air Component is a restructuring of the Plutonium in Airborne Particulates Network, which was comprised of monthly plutonium analyses from selected Radiation Alert Network sampling stations. The current sampling stations have been reoriented towards fuel processing, fuel reprocessing, and other facilities using plutonium or uranium. The Plutonium and Uranium in Air Component consists of 19 air sampling stations (figure 7) and are taken from the 19 continuously operated sampling stations of the ERAMS Gross Radioactivity and Deposition Component. Plutonium-238, plutonium-239, uranium-234, and uranium-238 analyses are performed on a quarterly composite from

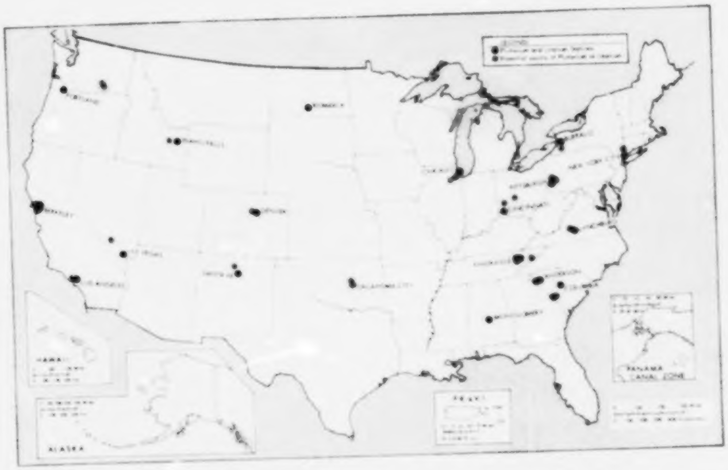

Figure 7. ERAMS Plutonium and Uranium in Air Component sampling locations

Table 6. ERAMS Plutonium and Uranium in Air Component, October–December 1973

Sampling location		Concentration [a] (aCi/m^3±2σ)				^{239}Pu[b]	Potential sources of plutonium or uranium
		^{234}U	^{238}U	^{238}Pu	^{239}Pu	^{238}Pu	
Ala:	Montgomery	20.5±1.8	17.9±1.6	0.7±0.3	3.9±0.7	6±3	Background
Calif:	Berkeley	7.7± .9	5.7± .7	.5± .2	2.7± .6	5±3	General Electric Company San Jose, Calif. Lawrence Berkeley Laboratory Berkeley, Claif. Lawrence Livermore Laboratory Livermore, Claif.
	Los Angeles	26.5±2.5	29.9±2.8	1.6± .4	4.3± .7	3±1	Atomics International Canoga Park, Calif.
Colo:	Denver	93.4±6.6	99.5±7.0	2.1± .6	8.7±1.2	4±1	Rocky Flats Plant Golden, Colo.
Idaho:	Idaho Falls	([c])					National Reactor Testing Station Idaho Falls, Idaho
Ill:	Chicago	([c])					Argonne National Laboratory Lemont., Ill. Midwest Fuel Reprocessing Plant Morris, Ill.
Nev:	Las Vegas	230±14	124±8.0	2.3± .7	10.8±1.6	5±2	Nevada Test Site Las Vegas, Nev.
N. Mex:	Santa Fe	39.2±3.9	48.1±4.5	3.5±1.0	8.5±1.6	2±1	Los Alamos Laboratory Los Alamos, N. Mex.
N.Y:	Buffalo	99.0±6.7	92.0±6.3	.8± .3	4.4± .8	6±3	Nuclear Fuel Services West Valley, N.Y.
	New York City	([c])					Gulf United Nuclear Fuels Pawling, N.Y.
N. Dak:	Bismarck	23.7±2.0	21.7±1.8	.2± .1	2.4± .5	12±9	Background
Ohio:	Columbus [d]	89.2±6.9	78.3±6.2	0	9.5±1.7	--------	Battelle Columbus Laboratory Columbus, Ohio Mound Laboratory Miamisburg, Ohio
Okla:	Oklahoma City	NS					Kerr-McGee Cimarron Plant Cresent, Okla.
Oreg:	Portland	6.4±1.1	6.8±1.2	1.0± .4	2.5± .6	3±1	Hanford Laboratories Richland, Wash. Exxon Nuclear Richland, Wash.
Pa:	Harrisburg [e]	33.8±3.0	32.5±2.9	1.0± .4	8.9±1.3	9±3	Westinghouse Cheswick, Pa. NUMEC—Babcock & Wilcox Leechburgh, Pa.
S.C:	Anderson	([c])					Westinghouse Fuels Recycle Anderson, S.C.
	Columbia	58.2±4.4	49.3±3.8	3.1± .7	5.3± .9	2±1	Savannah River Plant Aiken, S.C. Allied Gulf Nuclear Fuel Services Barnwell, S.C.
Tenn:	Knoxville	([c])					NFS Fuels Fabrication Plant Erwin, Tenn. Oak Ridge National Laboratory Oak Ridge, Tenn. LMFBR Demo Site Oak Ridge, Tenn.
Va:	Lynchburg	([c])					Babcock & Wilcox Lynchburg, Va.
Average		60.6	50.5	1.4	6.0	5	

[a] Any concentration less than the 2σ error has been reported as zero.
[b] Ratio calculated from raw data before rounding
[c] Station to be established.
[d] Staton to be relocated at Cincinnati.
[e] Station to be relocated at Pittsburgh.
NS, no sample.

each of the 19 sampling stations by the Eastern Environmental Radiation Facility, Montgomery, Ala. The volume of the air sampled ranged generally between 25 000 to 40 000 m^3 for each quarterly composite sample analyzed. The results from October–December 1973 are shown in table 6. The minimum detectable activities are 20, 15, 15, and 15 fCi per sample for plutonium-238, plutonium-239, uranium-234, and uranium-238, respectively.

Other coverage in *Radiation Data and Reports:*

Period	Issue
October–December 1972	June 1973
January–March 1973	May 1974
April–June 1973	June 1974
July–September 1973	September 1974

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1972[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since 1961, the strontium-90 content of human vertebrae has been measured by the Health and Safety Laboratory (HASL). In 1968, sampling in Chicago was discontinued. Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium-90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism, especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

During 1972, 284 specimens of human vertebrae were analyzed, including 53 from children and 67 from adults obtained in New York City and 100 from children and 64 from adults obtained in San Francisco. A summary of the results of strontium-90 determinations is given in table 1.

Table 1. Strontium-90 to calcium ratios in human vertebrae, 1972

Age	Strontium-90 to calcium ratios (pCi [a]^{90}Sr/g Ca)	
	New York City	San Francisco
0–1 week		0.52 (57)
1–7		.67 (14)
0–2 months	1.38 (7)	
1–7		1.42 (12)
6	2.91 (1)	
1–2 years	3.35 (2)	.83 (1)
2–3	2.88 (1)	.52 (1)
3–4	2.65 (1)	.77 (2)
4–5	2.56 (3)	.89 (1)
5–6	1.83 (2)	.68 (1)
6–7		1.30 (2)
7–8	1.86 (1)	
8–9	1.46 (1)	
9–10	1.68 (1)	
10–11	1.91 (2)	
11–12	1.99 (1)	.82 (2)
12–13		.95 (1)
13–14	1.57 (1)	
14–15	1.76 (2)	
15–16	1.31 (1)	
16–17	1.64 (6)	.91 (2)
17–18	1.92 (3)	
18–19	1.93 (12)	1.63 (1)
19–20	1.77 (5)	1.51 (3)
20–30	1.61 (23)	.88 (2)
30–40	1.41 (7)	.86 (9)
40–50	1.11 (8)	.85 (12)
50–60	1.54 (12)	.74 (17)
60–70	1.34 (7)	.64 (15)
70–80	1.45 (6)	1.17 (7)
80–90	1.53 (4)	1.05 (2)

[a] Number in parentheses indicates number of samples.

The strontium-90 to calcium ratios for adults are relatively constant, as has previously been observed. The variations about the mean are typical of such survey measurements. The average values and standard deviations for adult vertebrae in 1972 were 1.39 ± 0.39 pCi/g Ca in New York and 0.82 ± 0.34 pCi/g Ca in San Francisco.

The strontium-90 to calcium ratios for children's bone show more variation than the adult values. Generally higher values were obtained for children than adults in New York, but most values were within a factor of 1½ to 2 of the adult values. In San Francisco, the strontium-90 ratios for children had previously been slightly higher than for adults, and except for the 1–7 month old group, there is no longer any indication of higher values for children. Not a large number of samples were obtained during the year for the 1 to 20-year-age group. The highest value measured in New York vertebrae during 1972 was 4.18 pCi/g Ca for a 4-year-old child and in San Francisco, 2.82 pCi/g Ca for a 19-year-old.

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[1] Summarized from Fallout Quarterly Summary Reports, HASL–274 (July 1, 1972).

The higher strontium-90 concentration values in New York bone correspond to greater dietary strontium-90 intake. The strontium-90 to calcium ratios in total diet in New York and San Francisco during 1972 were 10.6 pCi/g Ca and 3.6 pCi/g Ca, respectively (*1*). These ratios in diet have decreased an average of 6 to 7 percent per year during the past 2 years.

Bone model

An improved bone model was formulated to correlate the strontium-90 concentrations in diet and bone (*2*). The model as it applies to adult vertebrae is described by the equation:

$$B_n = cD_n + g\sum_{m=0}^{\infty} D_{n-m}e^{-m\lambda} \qquad (1)$$

where,

B_n = ^{90}Sr concentrations in vertebrae in the year n (pCi)

D_n = ^{90}Sr concentration in diet from midyear in the year n–1 to midyear in the year n (pCi)

c = short-term retention of ^{90}Sr in bone

g = long-term retention of ^{90}Sr in bone, and

$1 - e^{-\lambda}$ = effective removal rate for ^{90}Sr in bone including radioactive decay (yr^{-1}).

The formula describes a two compartment model, one compartment associated with short-term retention of strontium on bone surfaces and another compartment in which the strontium is more tightly retained in bone. The parameters c and g are independent and not related to the previously used concept of observed ratio, since retention can also be associated with processes other than new bone formation. The effective removal rate or turnover rate for strontium-90 in bone is related to the rate of bone remodeling, but since strontium-calcium discrimination and reutilization are not explicit in the model, the removal rate can be considered to provide only an upper limit estimate of the actual bone renewal rate. The factors c, g, and λ are constant for adults (≧ age 20 years) but are age dependent for children.

Variations of the above bone model were investigated, such as the inclusion of an exponential in the short-term retention term. The best fit in this form, however, was with a very high order exponential, indicating essentially complete turnover of the short-term component during the course of a year.

The above formula for the bone model maintains a desired simplicity and yet gives adequate description of the year-to-year changes in strontium-90 content of bone. The values obtained for the model parameters allow reasonable interpretation.

Strontium-90 in adult vertebrae

The observed strontium-90 concentrations in adult vertebrae are shown in figure 1. Additional approximate values for the earliest years of contamination (1954–1959) in New York City from the data of Kulp and Schulert (*3*) have also been included. The adult data include only samples from individuals age 20 years or older in 1954, thus representing adult metabolism for the entire contamination period.

A definite decreasing trend in the observed values is apparent since 1965, corresponding to decreases in dietary strontium-90 intake. The relatively large standard deviations about the average values preclude extremely accurate determination of the actual decreases and thus the effective removal rates, however, these are becoming more firmly established as additional years of data accumulate during periods of decreasing strontium-90 levels in diet.

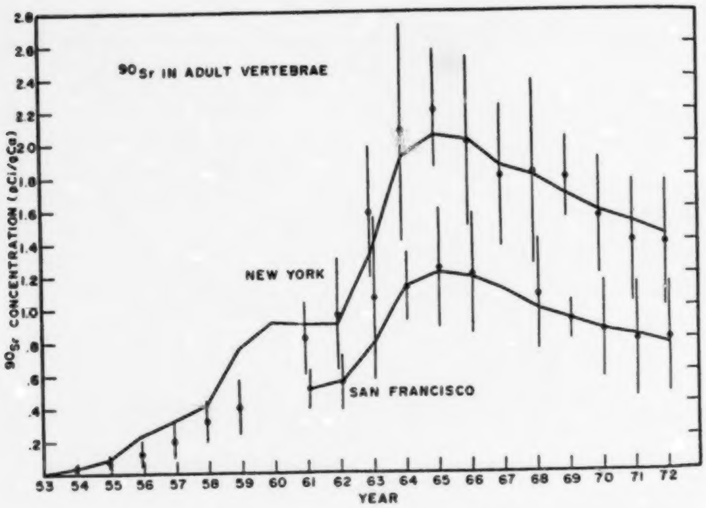

Figure 1. Strontium-90 in adult vertebrae—observations (points with standard deviations and bone model predictions, solid line)

From regression analysis of the measured New York City adult diet and vertebrae values through 1972 in the above bone model, one infers a turnover rate of strontium-90 from adult vertebrae of 20 percent per year. A turnover rate of 17 percent per year gives the best fit to the San Francisco adult data through 1972. The best fits to the observed data using the bone model are shown in figure 1.

The model shows peak strontium-90 concentrations in adult vertebrae in 1965, in agreement with observations. Subsequent decreases are achieved with a turnover rate which is reasonable, in view of the remodeling and diffusion processes occurring in bone. The bone model appears to be quite responsive to strontium-90 levels in diet and gives very satisfactory fits to the observed strontium-90 levels in vertebrae.

Strontium-90 in children's bone

The strontium-90 concentration in children's bone can be determined by the formula:

$$B_{i,n} = (c_i + g_i)\,D_{i,n} + [B_{i-1,n-1} - c_{i-1,}\,D_{i-1,n-1}]\,e^{-\lambda_i} \qquad (2)$$

The bone model parameters are defined as before. The subscript i indicates the age dependence.

For the newborn, the strontium-90 concentration can be related empirically to the mother's diet. The strontium-90 to calcium ratio in bone of newborn varies from 0.1 to 0.2 times the strontium-90 to calcium ratio in diet of the mother during the year prior to the birth. An average of about 0.15 is obtained from the survey data.

From the regression results for children, one infers that a one compartment, single exponential model ($c_i = 0$) applies to children under age 8 years. The one compartment formulation of the above model closely corresponds to the previously used Rivera bone model (4). The undifferentiated nature of bone of young children and the relatively high bone renewal rates justify the one compartment treatment.

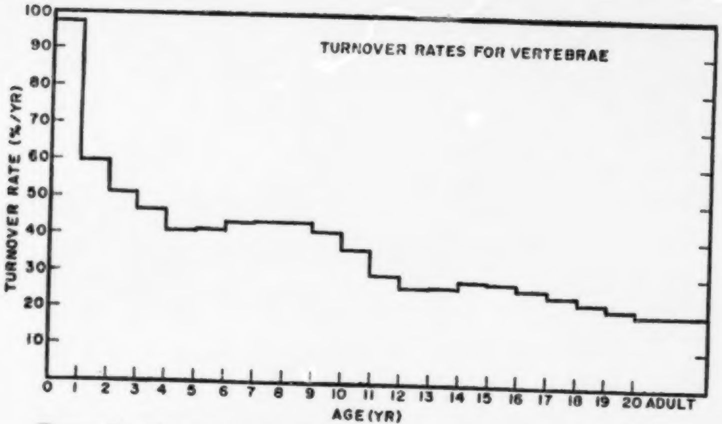

Figure 2. Turnover rates for vertebrae inferred from the two compartment bone models

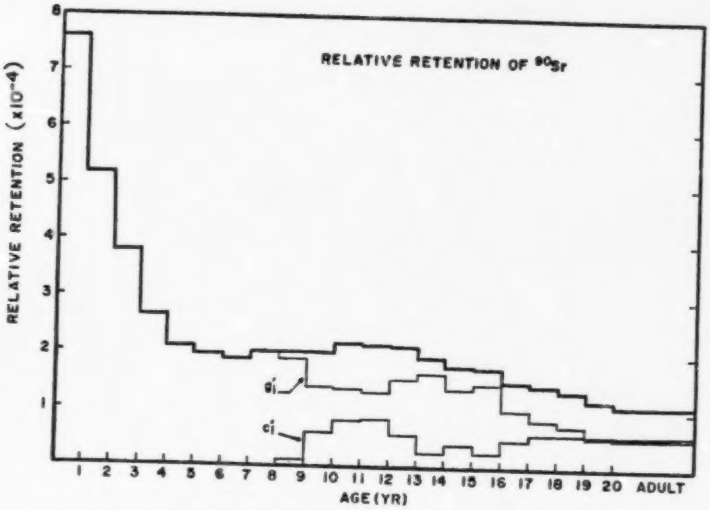

Figure 3. Retention of strontium-90 per gram skeletal calcium (the upper histogram is the total relative retention, c_i is the short-term component and g_i is the long-term component)

The strontium-90 turnover rates and relaive retention as a function of age are shown n figures 2 and 3. The turnover rates reflect bone growth activity and are highest for the youngest children. Nearly 100 percent per year turnover rate is indicated for the 0–1 year age range. A relatively high turnover rate, about 40 percent, is maintained through the preteenage years. The values then decrease to the adult value.

The relative retention of strontium-90 in bone, shown in figure 3, is the fractional retention of the dietary strontium-90 intake (c_i+g_i) per gram of skeletal calcium. The highest efficiency for strontium-90 retention is obtained for the youngest children. Increased efficiency associated with increased growth is also indicated for children in the early teenage years.

The magnitude of the relative retention was

C4

determined by assuming that vertebrae is representative of the entire skeleton. This assumption becomes less satisfactory for older children and adults. Initial estimates of body burden will be high and estimates at later times will be low, assuming less initial retention and slower turnover rates for compact bone. Integral results should be more representative for the entire skeleton, such as the cumulative dose results following a period of strontium-90 intake of 1 year or more.

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(2) BENNETT, B. G. Strontium-90 in human bone, 1971 results for New York City and San Francisco. U.S. Atomic Energy Commission, Health & Safety Laboratory (July 1972) pp. 1–51.

(3) KULP, J. L. and A. R. SCHULERT. Strontium-90 in man. Science 619:136 (1962).

(4) RIVERA, J. and J. H. HARLEY. The HASL bone program, 1961–1964, HASL-163. U.S. Atomic Energy Commission, Health & Safety Laboratory (August 1965).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available from local AEC operations offices or from the National Technical Information Service at a nominal cost. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports*. Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in the individual reports have been converted from the format required by the AEC to that used by *Radiation Data and Reports*. The Environmental Protection Agency has not independently nor critically reviewed the data nor the conclusion derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental data follow for Portsmouth Gaseous Diffusion Plant and Shippingport Atomic Power Station.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Portsmouth Area Gaseous Diffusion Plant[2]
January–December 1972

Goodyear Atomic Corporation
Piketon, Ohio

The Portsmouth Gaseous Diffusion Plant is owned by the U.S. Atomic Energy Commission and is operated by Goodyear Atomic Corporation, a subsidiary of the Goodyear Tire and Rubber Company. It is located in thinly populated, rural Pike County, Ohio, on a 16.2 km² site about 1.6 km east of the Scioto River Valley at an elevation about 37 m above the Scioto River flood plain. A map showing the plant size and its environs is presented in figure 1. The terrain surrounding the plant, except for the Scioto River flood plain, is marginal farm land and densely forested hills.

The principal process in the plant is the separation of uranium isotopes through gaseous diffusion. Ancillary processes include feeding material into and withdrawing material from the primary process; treatment of water for both sanitary and cooling purposes; decontamination of equipment removed from the plant for maintenance or replacement; recovery of uranium from various waste materials, such as decontamination solutions; and treatment of sewage wastes.

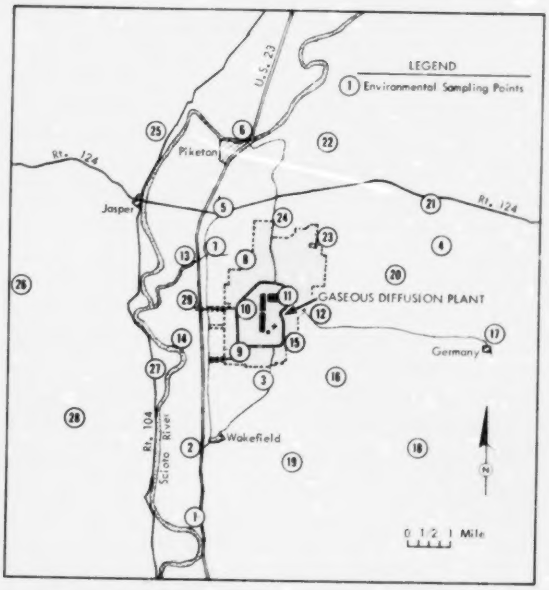

Figure 1. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

In the operation of a gaseous diffusion plant, as in the operation of any industrial plant, waste materials necessarily are generated as byproducts of the industrial processes. Since there is an ever present possibility that the wastes may contain environmental pollutants, including radioactive materials, the effluents from the various facilities are monitored carefully and frequently to assure that excessive quantities of pollutants and radioactive materials are not discharged into the environment. No streams from the plant are left unmonitored. Where necessary, treatment is provided to reduce concentrations to acceptable limits before the materials are discharged. In addition, water, air, and soil samples are collected routinely at many points both inside and outside the plant property to assure that the ambient environment has not been polluted with radioactive materials or other contaminants. Figure 1 shows the locations where samples normally are collected. This report describes the various environmental standards applicable to the Portsmouth Gaseous Diffusion Plant; the sampling, monitoring, and analytical procedures; and the extent of conformance with the standards.

Before July 1972, air samples were collected three times each week at four locations, identified as points 3, 12, 24, and 29 (figure 1). Each radioactivity sample, consisting of approximately 28 cubic meters of air, was passed through a Whatman #41 filter paper at about 0.56 cubic meter per minute. The material collected on the filter paper was analyzed for gross alpha and gross beta-gamma activities. In June, permanent sampling stations were installed at all four locations and in addition, a permanent sampling station was installed at location 28 in July. Air samples now are drawn through the filter paper, mounted on aperture IBM cards, at approximately 1.2 cubic meters per hour. The cards are changed once each week, after approximately 200 cubic meters of air are sampled.

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[2] Data summarized from "Portsmouth Gaseous Diffusion Plant Environmental Monitoring Report—1972."

Table 1. Radioactivity in air, Portsmouth Plant, January–December 1972

Location	Number of samples	Alpha radioactivity concentration (fCi/m³)		Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m³)		Average as a percent of AEC standards[a]
		Maximum	Average		Maximum	Average	
3	93	113±113	16± 5	0.40	1.594±0.398	0.209±0.057	0.02
12	96	177±177	17± 7	.43	1.787± .447	.211± .059	.02
24	91	403±101	17±10	.43	3 429± .857	.266± .095	.03
28	22	16± 16	5± 3	.13	.097± .024	.041± .015	.00
29	90	113±113	14± 5	.35	5.088±1.272	.284± .130	.03

[a] The AEC radiation protection standard for alpha radioactivity in air—4 000 fCi/m³; beta-gamma radioactivity—1 000 pCi/m³; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m³.

Table 2. Radioactivity in water, Portsmouth Plant, January–December 1972

Location	Number of samples	Water flow rate (m³/s)	Alpha radioactivity concentration (pCi/liter)		Average as a percent of AEC standards[a]	Number of samples	Beta-gamma radioactivity concentration (pCi/liter)		Average as a percent of AEC standards[a]
			Maximum	Average			Maximum	Average	
1	12	317.5	49.1± 25.0	7.7± 8.5	0.03	12	40.5± 2.8	6.8± 7.3	0.03
2	12	(b)	10.8± 5.0	4.1± 2.1	.01	12	ND	ND	----------
3	51	.011	40.1± 20.5	5.0± 2.0	.02	51	27.0± 1.9	6.7± 1.9	.03
4	12	(b)	5.0± 2.6	1.7± .9	.02	12	54.0± 3.8	7.5± 9.5	.04
5	12	(b)	17.6± 9.0	3.2± 3.1	.01	12	ND	ND	----------
6	44	317.5	9.9± 5.0	2.8± 1.1	.01	44	27.0± 1.9	3.7± 1.8	.02
7	18	.329	422.1±215.3	67.2±47.5	.22	18	639.0± 44.7	197.6±118.5	.99
8	18	.329	183.6± 93.6	54.3±25.9	.18	18	544.5± 38.1	10.1± 5.6	.84
10	51	.011	32.0± 16.3	5.4± 1.7	.02	51	103.5± 7.2	270.4±117.7	.05
11	51	.045	588.2±300.0	123.7±35.1	.41	51	2 313.0±161.9	8.3± 9.9	1.35
12	12	(b)	4.1± 2.1	1.4± .7	.005	12	54.0± 3.8	37.8± 21.6	.04
13	12	(b)	166.1± 84.7	39.3±36.7	.13	12	90.0± 6.3	6.2± 4.5	.19
14	17	317.5	40.5± 20.7	8.5± 5.5	.03	17	27.0± 1.9	----------	.03

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis' alpha radioactivity—0.5 pCi/liter; beta radioactivity—0.5 pCi/liter.

[b] Not measured.

ND, nondetectable.

Average alpha and beta-gamma radioactivity concentrations are summarized in table 1.

Two procedures are used for water sampling. Two-liter samples are taken monthly from the Scioto River and its tributaries, Little Beaver Creek, Big Beaver Creek, and Big Run. Composite samples are collected continuously (or at specific intervals) from the three principal drainage ditches serving the plant; sampling locations are identified on the map as points 3, 10, and 11. The composite samples are collected in 200-liter drums. Once each week, the water in the drums is mixed thoroughly, a 2-liter sample is withdrawn for analysis, and the drum is drained, cleaned, and installed again in the collection system. The 2-liter samples are analyzed for gross alpha and beta-gamma radioactivity. Radioactivity in water samples are shown in table 2.

External gamma radiation levels are measured routinely at locations 3, 12, 24, 28, and 29 to serve as indicators of background radiation. Measurements are made three times each week with a calibrated Geiger-Mueller tube at a distance of 1 meter above ground level. Average background rate for 1972 was 11.7 μR/h, which is not significantly different from the 1954 average rate, 11.9 μR/h. Background radioactivity is shown in table 3.

The data presented in the tables show clearly that radioactivity contamination of the environment is not a problem at the Portsmouth Gaseous Diffusion Plant. Maximum concentrations of alpha radioactivity in air, beta-gamma in air, alpha in water, and beta-gamma in water during 1972 were only 10.1 percent, 0.5 per-

Table 3. Background radiation, Portsmouth Plant January–December 1972

Location	Number of samples	Exposure rate [a] (μR/h)		Exposure [b] (mR)
		Maximum	Average	
3	113	24.3 ±3.6	12.0 ±0.6	105.1 ±5.3
12	113	26.0 ±3.9	11.2 ± .6	98.1 ±5.3
24	111	26.7 ±4.0	11.9 ± .6	104.2 ±5.3
28	42	19.8 ±3.0	11.6 ±1.0	101.6 ±8.7
29	110	21.4 ±3.2	11.8 ± .5	103.4 ±4.4

[a] Open-shield Geiger tube 0.9 meter above ground; limit of sensitivity—0.1 μR/h. Average background exposure rate for the Portsmouth Gaseous Diffusion Plant in 1954 was 11.9 μR/h, not significantly different from present rates.

[b] Total for the year.

cent, 2.0 percent, and 11.6 percent of the AEC standards, respectively. None of the averages was greater than 1.4 percent of the AEC standards. As may be seen in table 2, the only significant concentrations of radioactivity in water were found in samples taken downstream from the X-70-B holding point, which receives all radioactive decontamination solutions from the plant. In addition, the background radiation is essentially the same as it was in 1954. Obviously, there is no widespread radioactivity contamination occurring.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	January 1974

2. Shippingport Atomic Power Station[3] January–December 1972

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River on a 1.8 km^2 site. The site is approximately 1.6 km from Midland, Pa., 8 km from East Liverpool, Ohio, about 40 km west of Pittsburgh, and about 18 km below the confluence of the Beaver and Ohio Rivers (figure 2).

Operation of the pressurized water reactor at the Shippingport plant has supplied power to the Duquesne Light Company system, in addition to providing technology which has served as a basis for the development of pressurized water reactors in the nuclear industry. The present nuclear reactor installed at Shippingport is designed to produce 150 000 kilowatts of electrical power, although it is normally operated at or below the electric turbine-generator capacity of 100 000 kilowatts.

Liquid effluents from the plant are collected, processed, sampled, and analyzed to ensure conformance with the applicable water quality standards prior to release to the environment. Liquid effluents containing radioactivity are processed to reduce the amount of radioactivity to the lowest practical level. All releases of radioactivity from the plant site from initial operation to the present time have been carefully controlled to levels well below those specified in Atomic Energy Commission Manual Chapter 0524. Shippingport releases have been less than the limits agreed to with the Commonwealth of Pennsylvania. In addition, releases from the AEC contract portion of the power station have been in compliance with the water quality standards specified by Atomic Energy Commission Manual Chapter 0510 and have been within the guidelines established by the Ohio River Valley Water Sanitation Commission (*1*), and the Commonwealth of Pennsyl-

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[3] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Shippingport Atomic Power Station, January–December 1972."

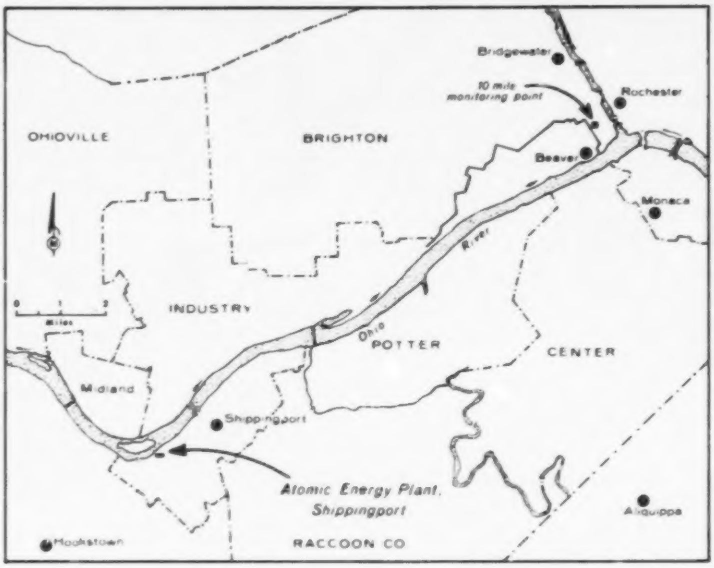

Figure 2. Shippingport Atomic Power Station sampling locations

vania (2). The results of environmental monitoring at Shippingport Atomic Power Station during 1972 show that plant operations have had no significant effect on the natural radiation levels in environment outside the station.

Effluent water quality

Water containing radioactivity is generated primarily from draining the reactor coolant system and decontaminating equipment. The plant is equipped with systems to collect and process this water and remove most of the radioactivity before it is released to the Ohio River.

The principal source of radioactivity in water from the reactor coolant system is trace amounts of corrosion and wear products from the inner metal surfaces of the reactor plant. The primary long-lived corrosion product radionuclide is cobalt-60, with a half-life of 5.3 years. This radionuclide has also been shown to be predominant by independent analysis by the Bettis Atomic Power Laboratory. In addition, a number of short-lived radionuclides are produced in the reactor coolant along with relatively long-lived tritium, which has a 12.3 year half-life. Because of the small initial concentrations and rapid decay, the concentrations of the short-lived radionuclides are negligible after holdup of the water in the radioactive liquid processing system, leaving the longer-lived cobalt-60 and tritium.

Fission product concentrations in the reactor coolant have been low relative to the levels of corrosion product radioactivity because the fuel element cladding has not had defects. Very low levels of fission products in reactor coolant are produced by fission of trace amounts of natural uranium impurities in the fuel cladding.

Prior to release from the site, water containing radioactivity is carefully processed through the radioactive liquid processing system to remove most of the radioactivity. This system includes filtration, ion exchange, evaporation, and equipment for monitoring the radioactivity levels in the holdup tanks.

During 1972, a total of 13 mCi of long-lived gross beta-gamma radioactivity, exclusive of tritium, and 670 mCi of tritium were released to the Ohio River. In addition, 1 mCi of fluorine-18 was released from the plant. Fluorine-18 has a half-life of less than 2 hours. These amounts of radioactivity are too small to have had any effect on the natural radioactivity levels in the Ohio River. The average concentration of radioactivity in water released to the Ohio River was 0.22 percent of the AEC standard for total activity, exclusive of tritium, and 0.018 percent of the concentration standard for tritium in water.

Gaseous radioactivity

Normal reactor operation produces radionuclides such as noble gases from the fission of trace impurities of natural uranium in reactor structurals and from irradiation of the reactor coolant water. Since there have been no defects in fuel element cladding, the fission products level in the reactor coolant have been low. Gases are removed from the reactor coolant system by venting to the gas system. The vent gas system contains the gases for sufficient time to permit radioactive decay and sampling of the gases for analyses prior to release to the environment.

A total of 1 mCi of radioactive gases, primarily xenon-133, was released from the vent gas system to the environment during 1972. In addition, an estimated 1 mCi of xenon-133 was released by all other paths from the plant. The total airborne and gaseous radioactivity, xenon-133, released from Shippingport over its operational history since December 1957 has been less than 1 curie. The small amount of gaseous radioactivity released from Shippingport has had no significant effect on the natural radiation levels in the surrounding area.

Environmental monitoring program

Environmental monitoring surveys adjacent to the Shippingport plant have been performed since prior to initial startup in 1957. A continuous environmental monitoring program has been carried out during the 15 years of plant operation to assure the adequacy of procedures and limits for the release of radioactivity. Water from both upstream and downstream sampling points in the Ohio River has been sampled continuously and analyzed weekly, sediment samples from the river have been taken from upstream and downstream sampling points quarterly and film badges around the boundary of the station and from a 16-km distance control point have been evaluated monthly. See figures 2 and 3 for monitoring and sampling locations. The results of these surveys have been reviewed both by the U.S. Atomic Energy Commission and the Commission's Bettis Atomic Power Laboratory.

In addition to the environmental monitoring program conducted by Duquesne Light Company, an independent environmental survey of the Ohio River in the vicinity of Shippingport was performed during November 1970 by Bettis Atomic Power Laboratory. Bettis Laboratory concluded that Shippingport Atomic Power Station operations have had no adverse effect on the Ohio River.

Ohio River water analysis

During 1972, weekly composite samples were analyzed from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive waste effluent release point. These samples were analyzed for gross alpha and beta-gamma radioactivity, on both suspended and dissolved solids, and also for potassium-40 content. As depicted in table 4, no significant difference was observed among the average alpha, beta-gamma and potassium-40 radioactivity for the influent and effluent samples for the river samples obtained during 1972.

Ohio River sediment analysis

The Ohio River bottom silt in the vicinity of Shippingport is sampled quarterly, to a depth of approximately 5 cm, upstream and downstream of the plant release point. During the years of plant operation, and even before plant operations began in 1957, measurements of sediment have shown a wide variation in radio-

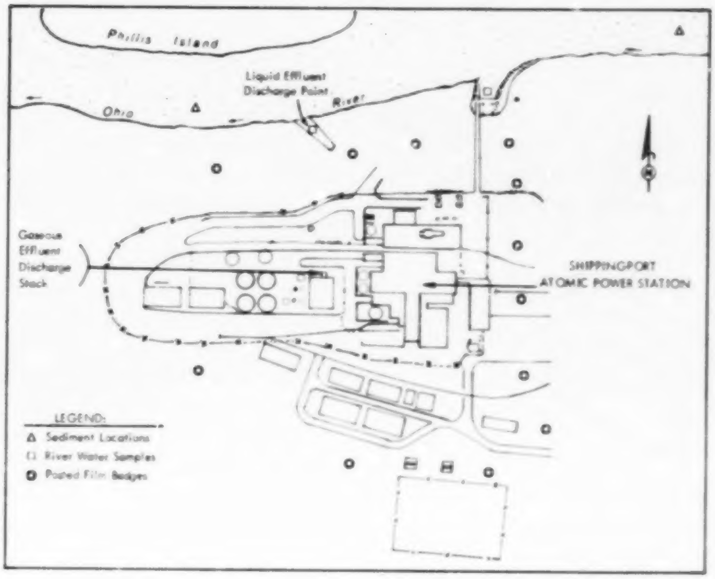
Phillis Island
Liquid Effluent Discharge Point
Ohio River
Gaseous Effluent Discharge Stack
SHIPPINGPORT ATOMIC POWER STATION
LEGEND:
△ Sediment Locations
□ River Water Samples
● Posted Film Badges

Figure 3. Shippingport liquid and gaseous effluent discharge points

Table 4. Gross radioactivity in the Ohio River, Shippingport Atomic Power Station, January–December 1972

Type of radioactive material	Number of samples per quarter [a]	Position	Average concentration (pCi/liter)			
			Jan–Mar	Apr–June	July–Sept	Oct–Dec
Alpha: [b]						
Total solids	13	Upstream	1.7	1.3	1.8	2.5
		Downstream	1.5	.9	1.3	2.9
Beta: [c]						
Total solids	13	Upstream	10.0	8.4	9.2	13.0
		Downstream	7.2	8.0	12.0	15.3
Potassium-40 [d]	13	Upstream	3.8	4.6	5.9	3.8
		Downstream	3.7	4.6	5.7	4.0

[a] The number of sample sets, both upstream and downstream.

[b] The 90-percent confidence level of average alpha radioactivity determinations is 0.2 pCi/liter.

[c] The 90-percent confidence level for average beta-gamma radioactivity determination is 0.7 pCi/liter.

[d] The 90-percent confidence level for average potassium-40 radioactivity determination is 0.4 pCi/liter.

activity, both upstream and downstream, caused by the radionuclides uranium, thorium, and daughter products of radium which occur naturally throughout the Ohio River basin and are washed into the river. Over the years, 1967 through 1971, the radioactivity in silt samples taken upstream from Shippingport, and thus reflecting natural radioactivity, varied between 2.5 and 17.0 pCi/g, with an average value of 8.2 pCi/g. This wide variation was also exhibited in the downstream silt measurements, which have an average value of 9.0 pCi/g.

In 1972, the river sediment sample activity averaged 2.4 pCi/g upstream and 2.8 pCi/g downstream, which is significantly below previous years. This is due to an improvement in counting capability which has provided a higher sensitivity. Since previous samples were within the minimum detectable activity range of previous methods, this greater sensitivity is reflected by activity values below those which were previously detectable. Consistent with the results of previous years, there is no significant difference between the 1972 upstream and downstream sediment sample activities. The small amount of radioactivity released from Shippingport Atomic Power Station has had no significant effect on the radioactivity levels of the river sediment.

Environmental radiation monitoring

Twelve beta-gamma film badges are posted and processed monthly throughout the year at the site perimeter. To determine the normal background levels of radiation in the vicinity of the station, a control film badge location is established 16 km from the station boundary in Bridgewater, Pa.

For the year 1972, the measured exposures on the site perimeter monitoring films were not measurably different from the natural background exposures on the control films. The monitoring results show that the radiation exposure to the general public outside the station is not above that received from natural background radiation.

Estimates of radiation dose to man

Even though the results of environmental monitoring show that the small amounts of radioactivity released from Shippingport have had no significant effect on the surrounding environment, conservative estimates of the radiation dose to man from radioactivity released have been made by analyzing the pathways whereby radioactivity might be transmitted from the environment to man. These analyses considered direct exposure, such as by drinking Ohio River water, and indirect pathways such as consumption of fish. These analyses showed the exposure to man from this radioactivity would be far too low to measure and could only be estimated through conservative calculation. Based on the radioactivity released during 1972 (table 5), the maximum radiation exposure in 1972 to any member of the general public would be less than 0.074 millirem. The maximum radiation exposure to any member of the general public and the exposure to the population within an 80-km radius of Shippingport are significantly less than 1 percent of the AEC standards. Thus, radioactivity released from Shippingport has not caused significant radiation exposure to the general public.

Conclusions

The small amounts of radioactivity released from Shippingport Atomic Power Station were far less than the limits specified by the Atomic Energy Commission and the Commonwealth of Pennsylvania. The results of the environmental monitoring described in this report show that Shippingport operations have had no significant effect on the environment around the plant.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	October 1973

Table 5. Annual liquid and gaseous radioactive waste discharges Shippingport Atomic Power Station, 1970–1972

Year	Radioactive liquid wastes released to the Ohio River				Gaseous wastes released to the environment (mCi)
	Total activity (excluding tritium) (mCi)	Percent of AEC standard	Tritium activity (Ci)	Percent of AEC standard	
1970	70	1.20	1.71	0.047	<1
1971	46	.79	.66	.018	[a] 0
1972	13	.22	.67	.018	1

[a] No gases were released due to adequate holdup capacity.

REFERENCES

(*1*) ORSANCO. Pollution Control Standard 1–70 and 2–70, Ohio River Valley Water Sanitation Commission ORSANCO, 414 Walnut Street, Cincinnati, Ohio 45202.

(*2*) COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF HEALTH. Sanitary Water Board, Industrial Wastes Permit No. 1832.

Erratum

An error occurred in table 3 (Laboratory gamma analysis of the dissolved component of water samples) page 44 of the report "A Radioactive Isotopic Characterization of the Environment Near Wiscasset Maine: . . ." that appeared in the February 1974 issue of *Radiation Data and Reports.* The second sample under "Young's Creek" should have appeared as the first sample under "Chewonki Neck." The corrected table appears below.

Table 3. Laboratory gamma analysis of the dissolved component of water samples [a]

Location and distance from reactor site	Type	Date collected (1972)	Date counted (1972)	Potassium [b] (g/liter $\pm 2\sigma$)	Cesium-137 (pCi/liter $\pm 2\sigma$)	Radon-222 (pCi/liter $\pm 2\sigma$)
Foxbird Island 0.1 km S	Estuarine	6/13	6/22	0.18±0.06	<2.0	<4.0
Eaton Farm 0.4 km W	Well	6/13	6/22	<.10	<2.0	<4.0
Bailey Farm 0.8 km NE	Well	6/13	6/22	<.10	<2.0	81.0±13.0
		6/13	6/29	<.10	<2.0	<4.0
Young's Creek 1.0 km N	Surface	6/13	6/22	<.10	<2.0	<4.0
Chewonki Neck (camp) 1.9 km SW	Well	6/13	6/22	<.10	<2.0	98.2±19.2
		6/13	6/27	<.10	<2.0	<4.0
Cowseagan Narrows 3.2 km NE	Estuarine	6/13	6/22	.19± .06	<2.0	<4.0
Bluff Head 4.0 km SSW	Estuarine	6/13	6/22	.16± .06	<2.0	<4.0

[a] All samples were counted for 50 minutes in a 3.5 liter Marinelli beaker geometry.

[b] Determined by measuring potassium-40

Reported Nuclear Detonations, September 1974

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission reported a nuclear test in the yield range of 20–200 kilotons was conducted at its Nevada Test Site on September 26, 1974, by the Atomic Energy Commission.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

☆U.S. GOVERNMENT PRINTING OFFICE: 1974 582–426/3

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL MONITORING AND DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES, 1973. ***M. E. Miles, G. L. Sjoblom, J. D. Eagles. Radiation Data and Reports, Vol. 15,*** **September 1974, pp. 625–646.**

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity, less tritium discharged to all ports and harbors from the more than 100 Naval nuclear-powered ships and supporting tenders, Naval bases and shipyards was less than 0.002 curie in 1973. The total tritium released to all ports and harbors was less than 1 curie in 1973. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

KEYWORDS: Discharges, disposal, harbors, monitoring, nuclear-powered ships, radioactivity, U.S. Naval, wastes.

RADIONUCLIDES IN FOODS: MONITORING PROGRAM. ***R. E. Simpson, E. J. Baratta,*** **and** ***C. F. Jelinek. Radiation Data and Reports, Vol. 15,*** **October 1974, pp. 647–656.**

In January 1973, the Food and Drug Administration notified its food monitoring program to include the radionuclides strontium-90, cesium-137, iodine-131, ruthenium-106, and potassium-40. Samples from eight composite food categories from each of eight separate total diet market baskets plus eight imported commodities from each of 13 separate cities were forwarded to the Winchester Engineering and Analytical Center for analysis. This paper describes the market basket program and gives a breakdown of the types of foods and quantities of each.

The radionuclide levels found in the total diets analyzed in Fiscal Year 1973 are within Range I of the appropriate guidelines, indicating the need for continued surveillance only at the present level.

The levels of radionuclides found in the limited types of edible imported commodities are low enough such that their contribution to the total diet would not be expected to raise the levels of these radionuclides above Range I of the guides.

KEYWORDS: Diet, food, cesium-137, iodine-131, potassium, ruthenium-106, strontium-90, United States.

RADIATION DATA AND REPORTS

Volume 15, Number 11, November 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

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SECTION I. MILK AND FOOD

Milk Surveillance, June 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological be-

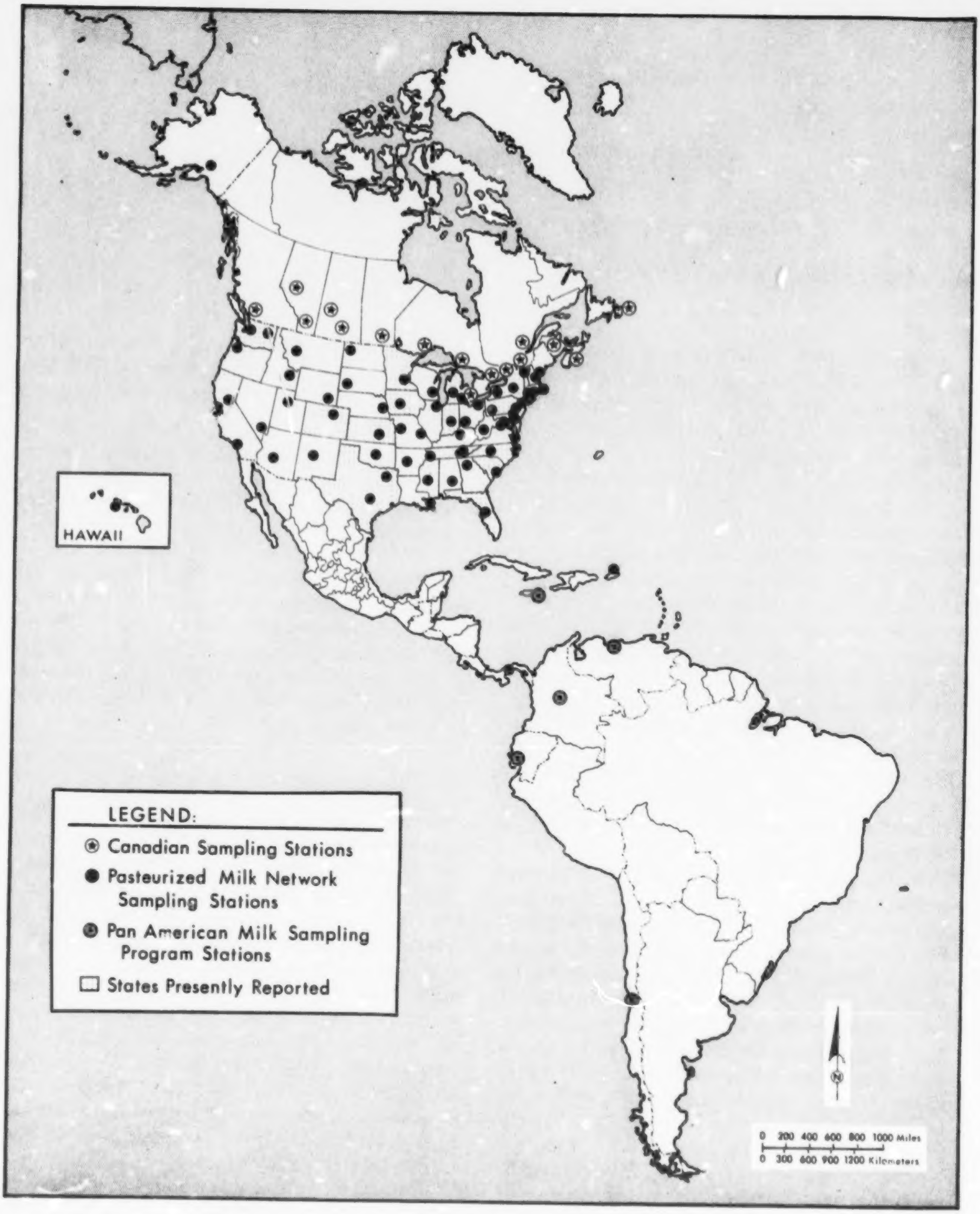
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

havior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (2) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131: (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137: (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89: (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90: (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analyses varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in connection of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the sta-

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	3	0	2
Alaska	Palmer[c]	P	NA	3	13	3
Ariz:	Phoenix[c]	P	NA	0	0	1
Ark:	Little Rock[c]	P	NA	12	11	3
Calif:	Los Angeles[c]	P	NA	0	0	0
	Sacramento[c]	P	NA	0	0	2
	San Francisco[c]	P	NA	0	0	0
	Del Norte	P	NA		NA	
	Fresno	P	NA		NA	
	Humboldt	P	NA		NA	
	Los Angeles	P	NA		NA	
	Mendocino	P	NA		NA	
	Sacramento	P	NA		NA	
	San Diego	P	NA		NA	
	Santa Clara	P	NA		NA	
	Shasta	P	NA		NA	
	Sonoma	P	NA		NA	
Colo:	Denver[c]	P	NA	0	0	0
	East	R	NS	NS	NS	NS
	Northeast	R	NS	NA	NS	4
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	0	0
	West	R	NS	NA	NS	0
Conn:	Hartford[c]	P	NA	4	16	1
	Central	P	NA		NA	
Del:	Wilmington[c]	P	NA	8	0	1
D.C:	Washington[c]	P	NA	4	0	1
Fla:	Tampa[c]	P	NA	4	20	25
	Central	R	3	5	15	26
	North	R	NA	6	19	13
	Northeast	R	4	6	18	25
	Southeast	R	5	5	34	41
	Tampa Bay area	P	4	4	17	24
	West	R	7	8	15	11
Ga:	Atlanta[c]	P	NA	4	14	3
Hawaii:	Honolulu[c]	P	NA	0	0	0
Idaho:	Idaho Falls[c]	P	NA	3	0	0
Ill:	Chicago[c]	P	NA	5	0	0
Ind:	Indianapolis[c]	P	NA	5	0	3
	Central	P	NA		NA	
	Northeast	P	NA		NA	
	Northwest	P	NA		NA	
	Southeast	P	NA		NA	
	Southwest	P	NA		NA	
Iowa:	Des Moines[c]	P	NA	4	0	0
	Des Moines	P	5	5	0	0
	Iowa City	P	6	5	0	0
	LeMars	P	NS	4	NS	0
	Little Cedar	P	6	6	0	0
Kans:	Wichita[c]	P	NA	6	11	2
	Coffeyville	P	9	6	NA	7
	Dodge City	P	4	4	NA	7
	Falls City, Nebr	R	NS	5	NA	8
	Hays	P	9	6	NA	5
	Kansas City	P	10	5	NA	5
	Topeka	P	10	6	NA	6
Ky:	Louisville[c]	P	NA	5	12	3
La:	New Orleans[c]	P	NA	8	13	6
Maine:	Portland[c]	P	NA	8	14	11
Md:	Baltimore[c]	P	NA	8	13	3
Mass:	Boston[c]	P	NA	8	13	5
Mich:	Detroit[c]	P	NA	6	0	3
	Grand Rapids[c]	P	NA	7	0	p
	Bay City	P	7	10	0	2
	Charlevoix	P	6	9	0	2
	Detroit	P	4	9	0	0
	Grand Rapids	P	11	13	0	5
	Lansing	P	10	11	0	3
	Marquette	P	9	12	15	6
	Monroe	P	30	14	0	2
	South Haven	P	11	14	0	2
Minn:	Minneapolis[c]	P	NA	7	0	0
	Bemidji	P	5	6	11	0
	Duluth	P	11	16	11	14
	Fergus Falls	P	7	7	0	0
	Little Falls	P	29	18	81	29
	Mankato	P	5	5	0	0
	Marshall	P	NS	3	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
Minn:	Minneapolis	P	11	9	0	0
	Rochester	P	6	5	0	0
Miss:	Jackson[c]	P	NA	8	0	4
Mo:	Kansas City[c]	P	NA	4	0	0
	St. Louis[c]	P	NA	8	14	2
Mont:	Helena[c]	P	NA	0	0	0
Nebr:	Omaha[c]	P	NA	0	11	1
Nev:	Las Vegas[c]	P	NA	8	0	0
N.H:	Manchester[c]	P	NA	9	13	5
N.J:	Trenton[c]	P	NA	4	12	1
N. Mex:	Albuquerque[c]	P	NA	0	0	0
N.Y:	Buffalo[c]	P	NA	6	0	0
	New York City[c]	P	NA	4	12	2
	Syracuse[c]	P	NA	6	14	3
	Albany	P	6 (3)	4	0	0
	Buffalo	P	3	5	0	0
	Massena	P	5	7	15	10
	New York City	P	9	6	0	0
	Syracuse	P	13	5	10	0
N.C:	Charlotte[c]	P	NA	9	12	5
	Asheville	P	7		0	
	Charlotte	P	8		14	
	Lexington	P	10		0	
	New Bern	P	7		15	
	Raleigh	P	7		13	
	Wilkesboro	P	10		22	
N. Dak:	Minot[c]	P	NA	6	11	1
Ohio:	Cincinnati[c]	P	NS	6	NS	3
	Cleveland[c]	P	NA	7	0	1
Okla:	Oklahoma City[c]	P	NA	2	14	1
Oreg:	Portland[c]	P	NA	0	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia[c]	P	NA	5	0	1
	Pittsburgh[c]	P	NA	10	11	2
	Dauphin	P	NA		NA	
	Erie	P	NA		NA	
	Philadelphia	P	NA		MA	
	Pittsburgh	P	NA		NA	
R.I:	Providence[c]	P	NA	4	14	6
S.C:	Charleston[c]	P	NA	5	17	9
	Anderson–01	R	7	7	0	2
	Anderson–02	R	6	6	0	3
	Chapin	R	NS	7	NS	8
	Clemson	R	6	8	0	8
	Columbia	R	NS	7	NS	11
	Fairfield	R	NS	6	NS	11
	Hartsville-02	R	6	6	11	9
	Hartsville-03	R	NS	13	NS	13
	Lee County	R	NS	7	NS	9
	Oconee County	R	7	7	0	5
	Pickens	R	7	7	0	9
	Williston	R	NS	7	NS	15
	Winnsboro	R	NS	6	NS	15
	York–01	R	NS	7	NS	5
	York–02	R	NS	5	NS	0
S. Dak:	Rapid City[c]	P	NA	8	0	1
Tenn:	Chattanooga[c]	P	NA	6	12	3
	Knoxville[c]	P	NA	0	13	3
	Memphis[c]	P	NA	6	0	2
	Chattanooga	P	NA	8	11	3
	Clinton	R	NA	9	14	3
	Fayetteville	R	NA	9	14	4
	Kingston	R	NA	9	18	3
	Knoxville	P	NA	7	12	4
	Lawrenceburg	R	NA	5	0	0
	Nashville	P	NS	6	NS	0
	Pulaski	R	NA	3	0	0
	Sequoyah	R	NS	9	NS	0
Tex:	Austin[c]	P	NA	0	0	0
	Dallas[c]	P	NA	3	11	1
Utah:	Salt Lake City[c]	P	NA	0	0	0
Vt:	Burlington[c]	P	NA	5	12	3
Va:	Norfolk[c]	P	NA	6	11	1
Wash:	Seattle[c]	P	NA	0	17	3
	Spokane[c]	P	NA	4	0	0
	Benton County	R	NS	0	NS	0
	Franklin County	R	0	1	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
Wash:	Longview	R	7	5	0	7
	Sandpoint, Idaho	R	7	5	0	1
	Skagit County	R	8	5	11	2
W. Va:	Charleston[c]	P	NA	8	12	1
Wisc:	Milwaukee[c]	P	NA	3	0	1
Wyo:	Laramie[c]	P	NA	0	0	1
CANADA:						
Alberta:	Calgary	P	NA		6	5
	Edmonton	P	NA		14	8
British Columbia:	Vancouver	P	NA		19	12
Manitoba:	Winnipeg	P	NA		8	8
New Brunswick:	Moncton	P	NA		10	8
Newfoundland:	St. John's	P	NA		27	15
Nova Scotia:	Halifax	P	NA		16	8
Ontario:	Ottawa	P	NA		9	6
	Sault Ste. Marie	P	NA		19	18
	Thunder Bay	P	NA		13	10
	Toronto	P	NA		6	5
	Windsor	P	NA		7	5
Quebec:	Montreal	P	NA		9	4
	Quebec	P	NA		16	12
Saskatchewan:	Regina	P	NA		7	4
	Saskatoon	P	NA		4	5
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal[c]	P	NA	0	0	0
Chile:	Santiago	P	0	0	18	2
Colombia:	Bogota	P	3	2	0	0
Ecuador:	Guayaquil	P	0	1	22	2
Jamaica:	Montego Bay	P	NS		NS	
Puerto Rico:	San Juan[c]	P	NA	3	12	2
Venezuela:	Caracas	P	0	0	0	0
PMN network average[d]			NA	5	6	2

[a] P, pasteurized milk,
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] This entry gives the average radionuclide concentrations for the Pasteurzied Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

tions which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for

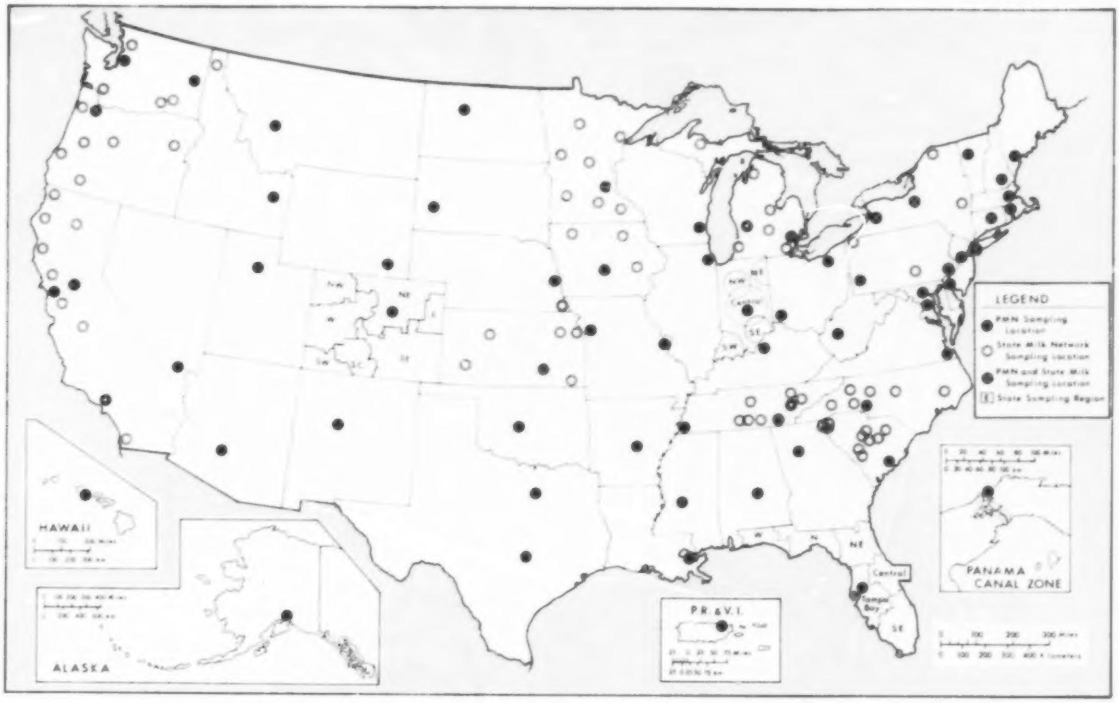
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R.&V.I.
PANAMA CANAL ZONE
NW
NE
W
SW
SC
SE
Central
Tampa Bay

Figure 2. State and PMN milk sampling stations in the United States

strontium-90 and cesium-137 for June 1974 and the 12-month period, July 1973 to June 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for June 1974 were below the respective practical reporting levels.

Strontium-90 monthly averages ranged from 0 to 30 pCi/liter in the United States for June 1974 and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 81 pCi/liter in the United States for June 1974, and the highest 12-month average was 41 pCi/liter (Southeast Florida) representing 1.1 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health
and Welfare

Radiological Health Section
Division of Occupational and Radiological
Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative
Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental
Conservation

Radiation Protection Branch
Division of Facility Services
North Carolina Department of Human
Resources

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and
Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Radiation Control Section
Division of Health
Washington Department of Social and
Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

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(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-90 measurements in milk, June 1972, Technical Experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analyses programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, HASL	1972	December 1973
Washington	July 1971–June 1972	October 1974

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas	1972	August 1974
Krypton-85 in air	July 1970–1972	March 1974

1. ERAMS Gross Radioactivity and Deposition Component, June 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage. The component consists of 74 sampling stations, 54 of which are on standby status and can be activated when the need arises. The remaining 20 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples, which are collected concurrently at the 20 air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

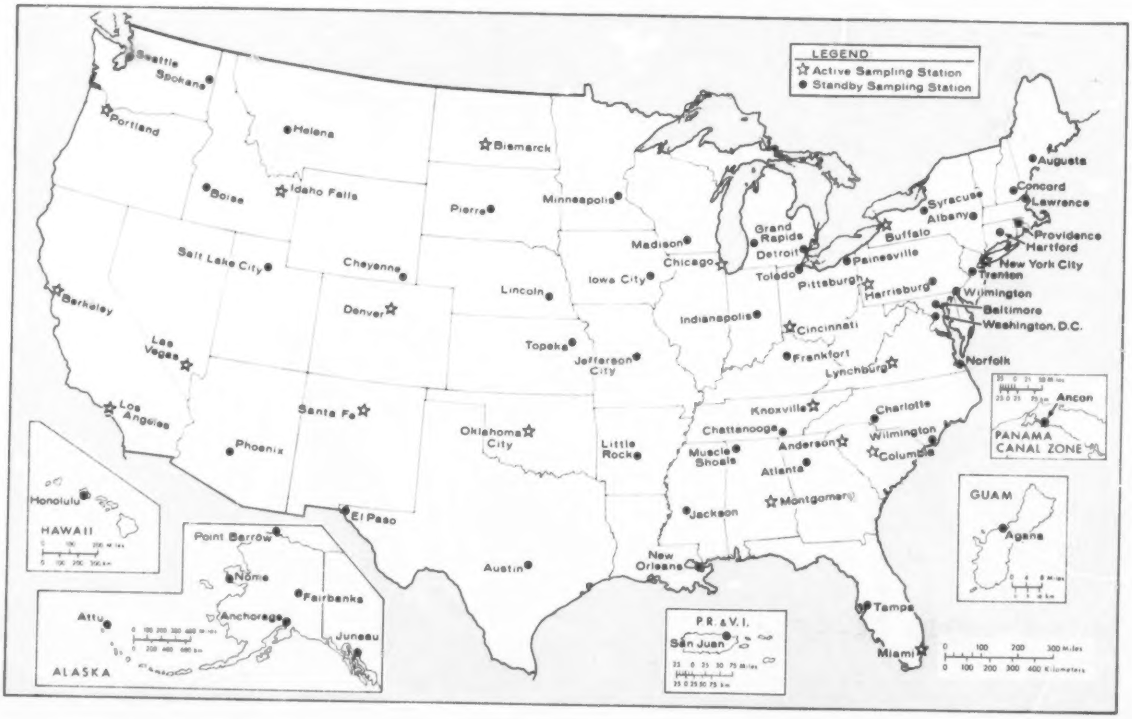
LEGEND
☆ Active Sampling Station
● Standby Sampling Station
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Idaho Falls
Pierre
Minneapolis
Augusta
Concord
Lawrence
Syracuse
Albany
Buffalo
Providence
Hartford
New York City
Trenton
Grand Rapids
Madison
Detroit
Chicago
Toledo
Painesville
Pittsburgh
Harrisburg
Wilmington
Baltimore
Washington, D.C.
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Cincinnati
Topeka
Jefferson City
Frankfort
Lynchburg
Norfolk
Las Vegas
Los Angeles
Santa Fe
Oklahoma City
Knoxville
Charlotte
Chattanooga
Wilmington
Little Rock
Muscle Shoals
Anderson
Columbia
Phoenix
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Tampa
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average ᵃ	Maximum	Minimum	Average ᵃ	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	12	2	0	1	0.20	0.09	0.14	56	0.47
	Muscle Shoals	0								
Alaska:	Anchorage	6	0	0	0	.05	.01	.03		
	Attu Island	9	0	0	0	.02	<.01	<.01		
	Fairbanks	7				.08	.03	.06		
	Juneau	0								
	Nome	0								
	Point Barrow	0								
Ariz:	Phoenix	3	3	1	2	.30	.20	.26		
Ark:	Little Rock	7	2	0	1	.23	.07	.14		
Calif:	Berkeley	15	0	0	0	.38	.05	.11		
	Los Angeles	13	3	0	1	.68	.03	.18		
C.Z:	Ancon	5	0	0	0	.02	<.01	.02		
Colo:	Denver	10	4	1	2	.30	.14	.20	40	.32
Conn:	Hartford	8	2	0	1	.16	<.01	.09		
Del:	Wilmington	6	1	0	0	.16	.03	.11		
D.C:	Washington	8	1	0	0	.28	.07	.15		
Fla:	Jacksonville ᵇ	6	1	0	0	.20	.07	.12		
	Miami	7	0	0	0	.08	.02	.05	55	.76
Ga:	Atlanta	6				.25	.16	.21		
Guam:	Agana	0								
Hawaii:	Honolulu	8	0	0	0	.35	.05	.11		
Idaho:	Boise	8	2	1	1	.38	.15	.22		
	Idaho Falls	8				.36	.13	.23		
Ill:	Chicago	5	5	0	2	.23	.07	.13		
Ind:	Indianapolis	4	0	0	0	.23	.10	.16		
Iowa:	Iowa City	4	4	1	2	.18	.15	.17		
Kans:	Topeka	8	6	1	3	.27	.07	.14		
Ky:	Frankfort	7	1	0	1	.13	.08	.10		
La:	New Orleans	5	1	0	1	.24	.11	.17		
Maine:	Augusta	7	1	0	0	.15	.03	.09		
Md:	Baltimore	7	1	0	1	.18	.05	.10	10	<.01
Mass:	Lawrence	0								
Mich:	Grand Rapids	0								
	Lansing ᶜ	5	2	0	1	.16	.08	.12	28	.50
Minn:	Minneapolis	3	2	1	2	.24	.18	.21		
Miss:	Jackson	7	2	0	1	.20	.09	.14	5	.07
Mo:	Jefferson City	6	5	0	3	.21	.08	.14	17	.15
Mont:	Helena	7	3	1	2	.30	.15	.20		
Nebr:	Lincoln	7	5	3	4	.82	.12	.29		
Nev:	Las Vegas	12	2	0	1	.44	.12	.23		
N.H:	Concord	0								
N.J:	Trenton	6	1	0	1	.18	.02	.09	41	1.23
N. Mex:	Santa Fe	12	2	0	1	.23	.09	.14		
N.Y:	Albany	4	1	0	1	.18	.02	.09		
	Buffalo	8	1	0	1	.37	.09	.25	2	.05
	New York City	6				.33	.04	.16		
	Syracuse	10				.20	.04	.10		
N.C:	Charlotte	0								
	Wilmington	0								
N. Dak:	Bismarck	13	7	1	3	.31	.13	.22	24	.96
Ohio:	Cincinnati	0								
	Columbus ᵈ	9	1	0	1	.26	.06	.14		
	Painesville	0								
Okla:	Oklahoma City	6	2	1	1	.21	.07	.14		
Oreg:	Portland	12	0	0	0	.18	.04	.10	27	.49
Pa:	Harrisburg	15	2	0	1	.27	<.01	.13	22	1.0
	Pittsburgh	0								
P.R:	San Juan	11				.13	.04	.09		
R.I:	Providence	8	1	0	1	.20	.02	.12		
S.C:	Anderson	0								
	Columbia	11	2	0	1	.29	.08	.17	79	1.96
S. Dak:	Pierre	11				.32	.17	.24		
Tenn:	Chattanooga	0								
	Nashville ᵉ	7	2	0	1	1.55	.09	.35	8	.09
Tex:	Austin	7	7	2	5	.27	.06	.16		
	El Paso	7	3	0	2	.23	.04	.11		
Utah:	Salt Lake City	0								
Va:	Lynchburg	5	1	0	1	.13	.06	.10		
	Norfolk	7	0	0	0	.27	.03	.11		
Wash:	Seattle	4	0	0	0	.09	.04	.07		
	Spokane	7	3	1	1	.18	.11	.15		
Wisc:	Madison	6	2	0	1	.19	.03	.14		
Wyo:	Cheyenne	6	4	0	2	.26	.12	.19		
Network summary		444	7	0	1	1.55	<0.01	0.14	30	0.58

ᵃ The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
ᵇ Station to be relocated to Tampa.
ᶜ Station to be relocated to Detroit.
ᵈ Station to be relocated to Toledo.
ᵉ Station to be relocated to Knoxville.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during June 1974. The standby stations were activated following the June 17, 1974 detonation of an atmospheric nuclear test by the Peoples Republic of China. Activity levels did not exceed those normally attributed to ambient variations.

2. Air Surveillance Network, June 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center —Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All standby stations except six stations near the NTS were activated on June 19 for the purpose of checking on the operability of the stations and collecting radioactive fallout from a nuclear detonation conducted by the Peoples Republic of China on June 16, 1974. All samples are mailed to the NERC-LV. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to one significant figure,

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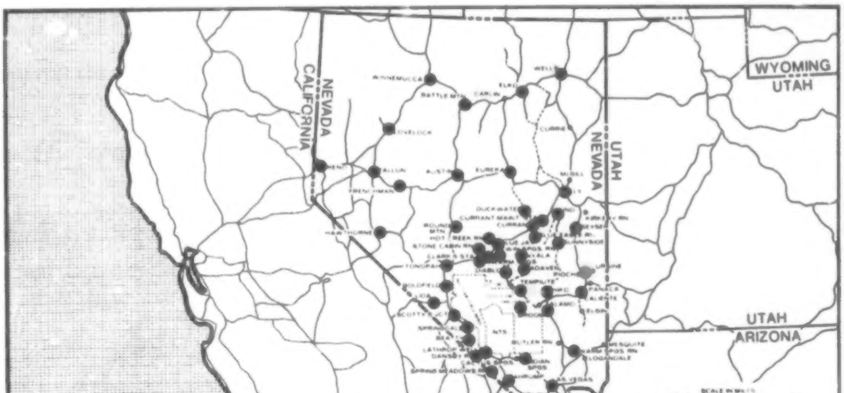
[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.


WYOMING
UTAH
NEVADA
CALIFORNIA
UTAH
NEVADA
UTAH
ARIZONA
WINNEMUCCA
BATTLE MTN
CARLIN
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WELLS
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
ELY
FRENCHMAN
DUCKWATER
CURRANT MAINT.
CURRANT
ROUND MTN
HAWTHORNE
HOT CREEK RN
STONE CABIN RN
BLUE JAY
CLARK'S STA.
TONOPAH
DIABLO
TEMPILUTE
PIOCHE
PANACA
CALIENTE
ELGIN
ALAMO
GOLDFIELD
SCOTTY'S JCT.
SPRINGDALE
BEATTY
NTS
BUTLER RN
MESQUITE
LOGANDALE
LATHROP WELLS
DANSBY
INDIAN SPGS
SPRING MEADOWS
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 70 100 150

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

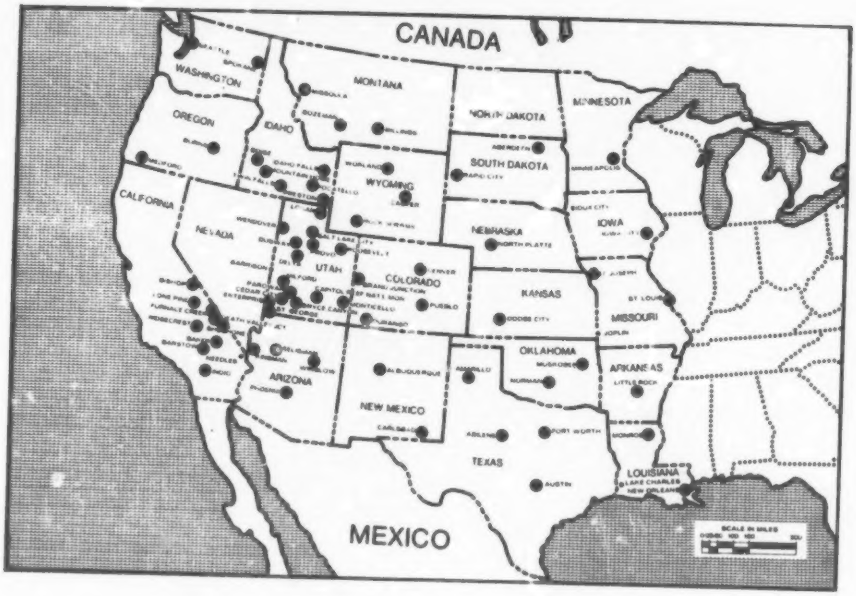
CANADA
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
WORLAND
WYOMING
CASPER
ROCK SPRINGS
CALIFORNIA
NEVADA
WENDOVER
SALT LAKE CITY
PROVO
DELTA
GARRISON
UTAH
VERNAL
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
CAPITOL REEF NAT'L MON
BRYCE CANYON
MONTICELLO
DURANGO
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
BISHOP
LONE PINE
FURNACE CREEK
DEATH VALLEY JCT
RIDGECREST
BAKER
BARSTOW
NEEDLES
INDIO
KINGMAN
SELIGMAN
WINSLOW
ARIZONA
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNESOTA
MINNEAPOLIS
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
ST JOSEPH
ST LOUIS
MISSOURI
JOPLIN
OKLAHOMA
MUSKOGEE
NORMAN
AMARILLO
ARKANSAS
LITTLE ROCK
TEXAS
ABILENE
FORT WORTH
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
SCALE IN MILES

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

and those equal to or greater than 1.0 pCi/m^3 are reported to two significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (~0.03 pCi/m^3 for a 700 m^3 sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are as follows:

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	<0.1	<0.1
≥ 0.05 <0.15	0.1	<0.1
≥ 0.15	As calculated and rounded	< calculated MDC

As shown by table 2, the highest gross beta concentration at stations within the network was 2.7 pCi/m^3 at Bishop, Calif., during June 7–10, 1974.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-106 and cerium-144 were identified on filters collected throughout the network. The maximum concentrations (pCi/m^3) of these radionuclides were as follows: zirconium-95, 0.41 pCi/m^3 at Bishop, Calif. on June 7–10; ruthenium-106, 0.62 pCi/m^3 at Logan, Utah on June 26–28; and cerium-144, 0.83 pCi/m^3 at Bishop, Calif. on June 19–21, 1974.

These radionuclides are attributed to seasonal variations in worldwide fallout. No radioactivity from the nuclear detonation by the Peoples Republic of China was detected. No radionuclides were identified by gamma spectrometry on any charcoal cartridges during June.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentration in air, June 1974

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	12	0.9	<0.1	0.4
	Phoenix	4	.3	.2	.2
	Seligman	12	.4	<.1	.2
	Winslow	5	.2	.1	.2
Ark:	Little Rock	5	.3	.1	.2
Calif:	Baker	16	.9	.2	.5
	Barstow	15	.9	.1	.4
	Bishop	12	2.7	.3	.8
	Death Valley Junction	13	.9	.2	.5
	Furnace Creek	11	1.0	.3	.6
	Indio	5	.4	.2	.3
	Lone Pine	16	.9	.2	.4
	Needles	6	.5	.2	.3
	Ridgecrest	12	.5	.2	.3
	Shoshone	12	1.3	.2	.4
Colo:	Denver	5	.8	.2	.4
	Durango	5	.5	.1	.2
Idaho:	Boise	5	.4	.3	.4
	Idaho Falls	4	.6	.2	.4
	Preston	6	.6	.3	.4
	Twin Falls	5	.5	.2	.4
Iowa:	Iowa City	5	.3	.1	.2
	Sioux City	4	.5	.3	.4
Kans:	Dodge City	4	.2	.1	.2
La:	Lake Charles	5	.4	.2	.3
	Monroe	5	.3	.1	.2
	New Orleans	6	.4	.2	.3
Minn:	Minneapolis	5	.4	.2	.3
Mo:	Clayton	5	.4	.1	.2
	Joplin	5	.3	.1	.2
	St. Joseph	4	.5	.1	.3
Nebr:	North Platte	6	.5	.2	.4
Nev:	Alamo	12	.6	.2	.3
	Austin	3	.5	.1	.4
	Battle Mountain	5	.6	.2	.4
	Beatty	12	.7	.2	.4
	Blue Eagle Ranch (Currant)	12	.7	.1	.4
	Blue Jay	12	.7	.1	.3
	Caliente	11	.7	.2	.4
	Currant Ranch	12	.6	.2	.4
	Currie	5	.4	.2	.3
	Diablo	12	.8	.2	.4
	Duckwater	10	.6	.1	.3
	Elko	5	.5	.2	.4
	Ely	8	.5	.1	.3
	Eureka	10	.5	.1	.4
	Fallini's Twin Springs Ranch	12	.6	<.1	.4
	Fallon	5	.6	.3	.5
	Geyser Ranch (Pioche)	2	.5	.3	.4
	Goldfield	10	1.7	.2	.5
	Groom Lake	12	.9	.2	.5
	Hiko	12	.7	.2	.4
	Indian Springs	12	.5	.1	.2
	Las Vegas	20	.9	.2	.4
	Lathrop Wells	12	.9	.2	.4
	Lida	7	.5	<.1	.2
	Lovelock	2	.4	.4	.4
	Lund	12	.6	.1	.4
	Mesquite	12	.6	.1	.3
	Nyala	12	.7	<.1	.4
	Pahrump	10	.6	.1	.3
	Pioche	12	.6	.2	.3
	Reno	5	.7	.4	.4
	Round Mountain	12	.9	.1	.4
	Scotty's Junction	12	.8	.2	.5
	Stone Cabin Ranch	12	.4	<.1	.2
	Sunnyside	12	.5	.1	.3
	Tonopah	11	.8	.2	.5
	Tonopah Test Range	9	.6	.2	.4
	Warm Springs	2	.6	.2	.3
	Warm Springs Ranch	10	.6	.1	.4
	Wells	5	.7	.2	.5
	Winnemucca	5	.5	.3	.4
N. Mex:	Albuquerque	5	.2	.2	.2
	Carlsbad	5	.4	<.1	.2
Oreg:	Burns	3	.4	.3	.4
S. Dak:	Aberdeen	5	.4	.2	.3
	Rapid City	5	.6	.2	.4
Tex:	Abilene	5	.4	.1	.3
	Austin	5	.3	.1	.2
	Fort Worth	5	.3	<.1	.2
Utah:	Bryce Canyon	10	.6	.1	.2
	Cedar City	8	.5	.1	.3
	Delta	12	.4	.1	.2
	Dugway	5	.5	.2	.4
	Enterprise	5	.4	.2	.3
	Garrison	12	.5	.2	.4
	Logan	5	1.2	.1	.5

Table 2. Summary of gross beta radioactivity concentration in air, June 1974—continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average
Utah:	Milford	10	.5	.1	.2
	Monticello	5	.5	.1	.2
	Parowan	5	.4	.1	.2
	Provo	5	.8	.2	.4
	Salt Lake City	12	.7	.2	.4
	St. George	13	1.1	.1	.4
	Vernal	2	.3	.2	.2
	Wendover	4	.6	.3	.5
Wash:	Seattle	5	.2	<.1	.1
	Spokane	5	.3	.2	.3
Wyo:	Rock Springs	5	.5	.2	.3
	Worland	5	.7	.3	.4

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3. Canadian Air and Precipitation Monitoring Program,[3] June 1974

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1974 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, June 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	13	0.38	0.08	0.23	216.0	4.3
Coral Harbour	13	.24	.07	.16	56.0	2.5
Edmonton	13	.36	.15	.26	48.9	4.2
Ft. Churchill	14	.23	.01	.12	67.4	4.3
Fredericton	12	.17	.04	.11	65.7	4.4
Goose Bay	15	.17	.01	.09	27.5	1.6
Halifax	14	.24	.02	.13	59.3	5.3
Inuvik	10	.24	.02	.13	92.7	1.7
Montreal	14	.28	.05	.17	95.1	6.3
Moosonee	13	.28	.01	.15	NS	
Ottawa	13	.17	.03	.10	113.0	4.7
Quebec	15	.19	.08	.14	44.0	5.6
Regina	13	.93	.11	.52	100.2	2.3
Resolute	4	.09	.05	.07	150.7	2.2
St. John's, Nfld	2	.20	.02	.11	NS	
Saskatoon	12	.34	.07	.21	111.0	6.8
Sault Ste. Marie	11	.24	.02	.13	72.7	9.4
Thunder Bay	15	.25	.03	.14	89.5	9.1
Toronto	NS	------	------	------	21.2	2.8
Vancouver	12	.28	.04	.16	155.2	3.1
Whitehorse	13	.22	.01	.12	101.7	3.9
Windsor	NS	------	------	------	97.8	4.9
Winnipeg	15	3.11	.13	1.62	243.3	4.3
Yellowknife	15	.20	.17	.19	90.7	5.8
Network summary	281	3.11	0.01	0.23	96.3	4.5

NA, not available.
NS, no sample.

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

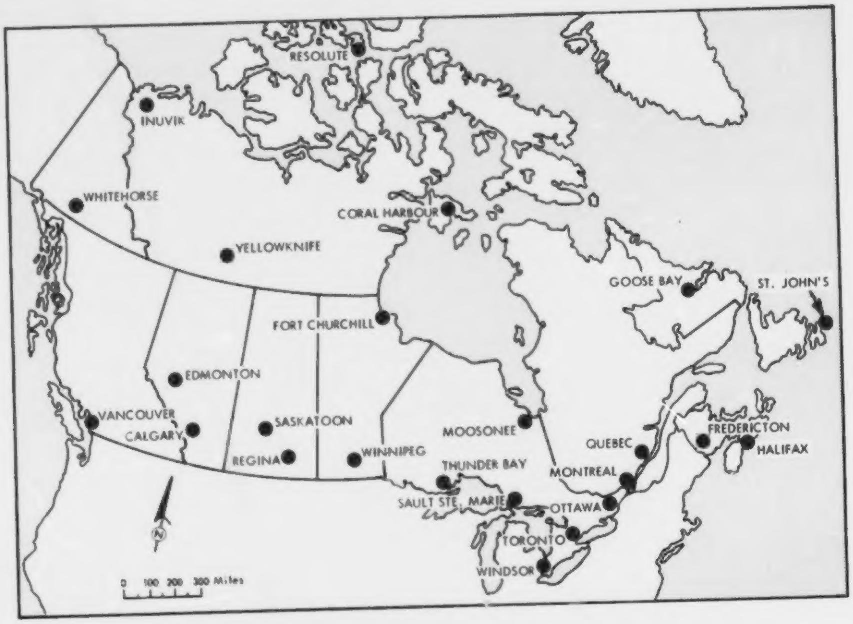
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air and precipitation sampling stations

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(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

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(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

4. Pan American Air Sampling Program, June 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1974 air monitoring results from the participating countries are given in table 4.

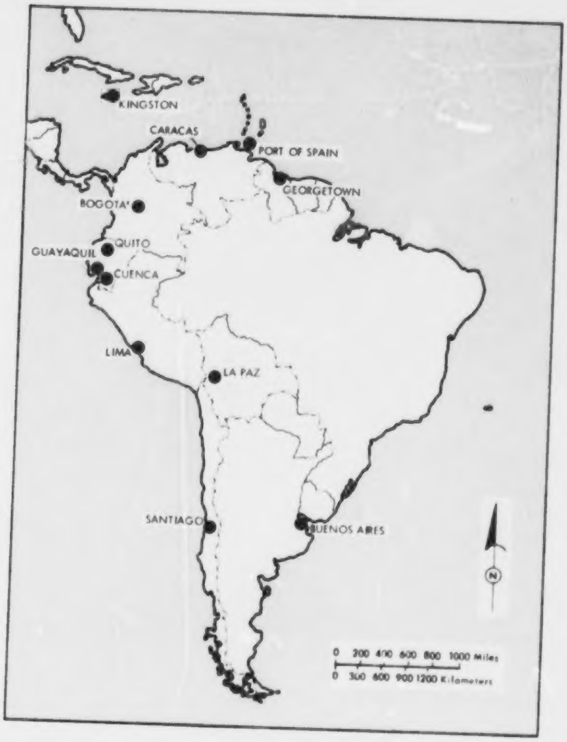

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, June 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average ᵃ
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	25	0.15	0.00	0.02
Colombia:	Bogota	18	.03	.00	.01
Ecuador:	Cuenca	1	.00	.00	.00
	Guayaquil	19	.02	.01	.01
	Quito	6	.00	.00	.00
Guyana:	Georgetown	1	.01	.01	.01
Jamaica:	Kingston	0			
Peru:	Lima	17	.01	.00	.01
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	0			
Pam American summary		87	0.15	0.00	0.01

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program, June 1974

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for June 1974.

Table 5. Gross beta radioactivity in California air, June 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	22	1.36	0.14	0.70
Barstow	30	1.34	.18	.60
Berkeley	30	.63	.03	.26
Diablo Canyon Nuclear Power Plant	9	.47	.03	.23
El Centro	21	1.07	.11	.52
Eureka	22	.55	.06	.18
Fresno	19	1.13	.10	.57
Humboldt Bay Nuclear Power Plant	14	.39	.06	.17
Livermore	21	.82	.06	.35
Los Angeles	18	1.03	.06	.31
Rancho Seco Nuclear Power Plant	14	.93	.14	.45
Redding	17	1.78	.47	1.01
Sacramento	20	.74	.07	.31
Salinas	12	.40	.06	.22
San Bernardino	17	.73	.22	.46
San Diego	20	.56	.05	.28
San Luis Obispo	19	.52	.03	.26
San Onofre Nuclear Generating Station	5	.46	.21	.28
Summary	330	1.78	0.03	0.40

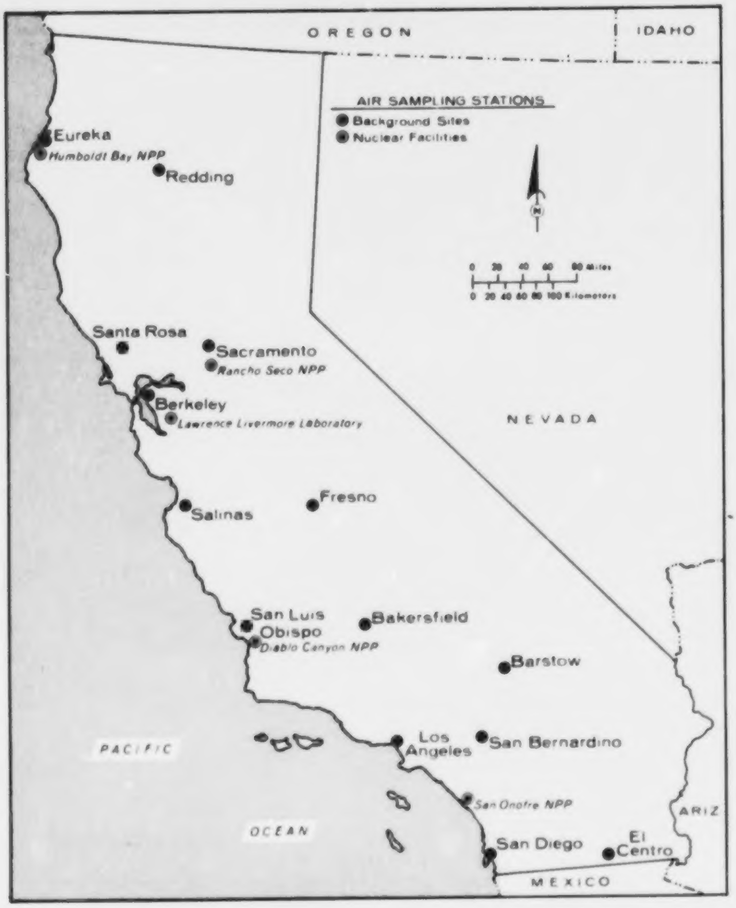
OREGON
IDAHO
AIR SAMPLING STATIONS
● Background Sites
● Nuclear Facilities
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Humboldt Bay NPP
Redding
Santa Rosa
Sacramento
Rancho Seco NPP
Berkeley
Lawrence Livermore Laboratory
NEVADA
Salinas
Fresno
San Luis Obispo
Diablo Canyon NPP
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
San Onofre NPP
ARIZ
San Diego
El Centro
MEXICO

Figure 6. California air sampling program stations

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6. Mexican Air Monitoring Program January–June 1974

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CRS) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

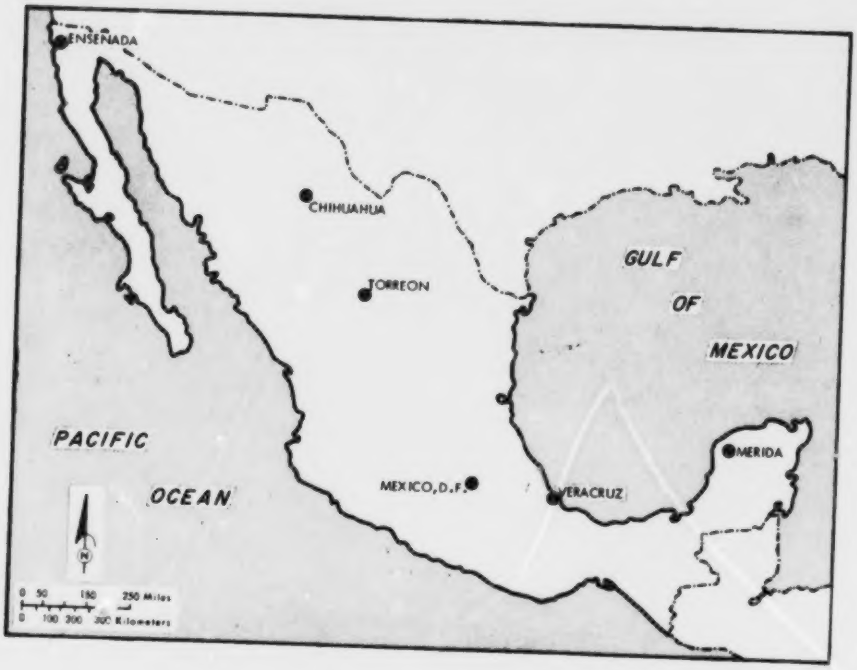
ENSENADA
CHIHUAHUA
TORREON
GULF OF MEXICO
PACIFIC OCEAN
MERIDA
MEXICO, D.F.
VERACRUZ
N
0 50 150 250 Miles
0 100 200 300 Kilometers

Figure 7. Mexican air sampling locations

Table 6. Mexican gross beta radioactivity of airborne particulates, January-June 1974

Station	Gross beta radioactivity (pCi/m³)					
	Jan	Feb	Mar	Apr	May	June
Chihuahua:						
Maximum	0.10	0.25	0.34	0.24	0.30	0.57
Minimum	.08	.22	.10	.14	.22	.18
Average	(a)	(a)	(a)	.16	.26	.33
Ensenada:						
Maximum	NS	NS	.70	.47	.63	.33
Minimum	NS	NS	.17	.17	.14	.16
Average	NS	NS	.44	.35	.30	.24
Mérida:						
Maximum	.39	.44	.57	.20	.23	.31
Minimum	.07	.15	.16	.09	.09	.07
Average	.14	.27	.29	.12	.18	.19
México, D.F:						
Maximum	.16	.26	.36	NS	NS	.50
Minimum	.10	.18	.18	NS	NS	.09
Average	.12	.20	(a)	NS	NS	.25
Torreón:						
Maximum	.33	.32	.44	.28	.37	.41
Minimum	.05	.25	.18	.12	.17	.19
Average	.15	.28	.31	.22	.21	.27
Veracruz:						
Maximum	NS	NS	NS	NS	.19	.59
Minimum	NS	NS	NS	NS	.05	<.04
Average	NS	NS	NS	NS	.11	.20

[a] Average not calculated for less than 5 samples.
NS, no sample.

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua; Ensenada, Torreón; Veracruz, and Mérida (figure 7). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from January through June 1974 are presented in table 6. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August–December 1970 and January 1971. Radiol Health Data Rep 12:525–528 (October 1971).

(*7*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

ERAMS Plutonium and Uranium in Air Component, January-March 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973 was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Plutonium and Uranium in Air Component is a restructuring of the Plutonium in Airborne Particulates network, which was comprised of monthly plutonium analyses from selected Radiation Alert Network sampling stations. The current sampling stations have been reoriented towards fuel processing, fuel reprocessing, and other facilities using plutonium or uranium. The Plutonium and Uranium in Air Component consists of 19 air sampling stations (figure 1) and are taken from the 19 continuously operated sampling stations of the ERAMS Gross Radioactivity and Deposition Component. Plutonium-238, plutonium-239, uranium-234, and uranium-238 analyses are performed on a quarterly composite from each of the 19 sampling stations by the Eastern Environmental Radiation Facility, Montgomery, Ala. The volume of the air sampled ranged generally between 25 000 to 40 000 m^3 for each quarterly composite sample analyzed. The results from January–March 1974 are shown in table 1. The minimum detectable activities are 20, 15, 15, and 15 fCi per sample for plutonium-238, plutonium-239, uranium-234, and uranium-238, respectively.

Other coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1973	May 1974
April–June 1973	June 1974
July–September 1973	September 1974
October–December 1973	October 1974

Table 1. ERAMS Plutonium and Uranium in Air Component, January-March 1974

Sampling location		Concentration [a] (aCi/m³±2σ)				(^{239}Pu/^{238}Pu) [b]	Potential sources of plutonium or uranium
		^{234}U	^{238}U	^{238}Pu	^{239}Pu		
Ala:	Montgomery	15.2±1.3	12.8±1.2	0.3±0.2	19.7±1.9	62±31	Background
Calif:	Berkeley	7.9± .9	7.4± .8	2.0± .5	13.1±1.4	7± 2	General Electric Company San Jose, Calif. Lawrence Berkeley Laboratory Berkeley, Calif. Lawrence Livermore Laboratory Livermore, Calif.
	Los Angeles	19.0±1.6	20.4±1.7	1.9± .5	19.2±2.1	10± 3	Atomics International Canoga Park, Calif.
Colo:	Denver	101 ±6.4	108 ±6.8	2.6± .8	39.7±4.8	15± 5	Rocky Flats Plant Golden, Colo.
Idaho:	Idaho Falls	39.0±2.7	35.9±2.5	2.0± .5	16.2±1.8	8± 2	National Reactor Testing Station Idaho Falls, Idaho
Ill:	Chicago	(c)					Argonne National Laboratory Lemont., Ill. Midwest Fuel Reprocessing Plant Morris, Ill.
Nev:	Las Vegas	140 ±8.5	71.6±4.7	4.2± .9	18.0±2.3	4± 1	Nevada Test Site Las Vegas, Nev.
N. Mex:	Santa Fe	37.7±2.9	40.2±3.0	1.7± .5	26.2±2.8	15± 5	Los Alamos Laboratory Los Alamos, N. Mex.
N.Y:	Buffalo	70.7±4.7	70.0±4.6	2.2± .6	14.2±1.7	7± 2	Nuclear Fuel Services West Valley, N.Y.
	New York City	(c)					Gulf United Nuclear Fuels Pawling, N.Y.
N. Dak:	Bismarck	54.7±3.6	50.6±3.3	1.8± .5	14.3±1.6	8± 2	Background
Ohio:	Columbus [d]	90.7±5.9	91.6±6.0	.5± .2	13.8±1.5	26±12	Battelle Columbus Laboratory Columbus, Ohio Mound Laboratory Miamisburg, Ohio
Okla:	Oklahoma City	36.9±3.0	35.2±2.9	1.7± .5	24.1±2.6	14± 5	Kerr-McGee Cimarron Plant Cresent, Okla.
Oreg:	Portland	22.1±2.0	19.6±1.8	2.6± .5	11.1±1.2	4± 1	Hanford Laboratories Richland, Wash Exxon Nuclear Richland, Wash.
Pa:	Harrisburg [e]	24.6±2.5	24.4±2.4	1.3± .4	14.1±1.7	11± 4	Westinghouse Cheswick, Pa. NUMEC—Babcock & Wilcox Leechburgh, Pa.
S.C:	Anderson	(c)					Westinghouse Fuels Recycle Anderson, S.C.
	Columbia	32.5±2.3	30.4±2.2	1.0± .3	15.9±1.6	17± 5	Savannah River Plant Aiken, S.C. Allied Gulf Nuclear Fuel Services Barnwell, S.C.
Tenn:	Knoxville	(c)					NFS Fuels Fabrication Plant Erwin, Tenn. Oak Ridge National Laboratory Oak Ridge, Tenn. LMFBR Demo Site Oak Ridge, Tenn.
Va:	Lynchburg	(c)					Babcock & Wilcox Lynchburg, Va.
Average		49.4	44.2	1.8	18.5	15	

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[a] Any concentration less than the 2σ error has been reported as zero.
[b] Ratio calculated from raw data before rounding.
[c] Station to be established.
[d] Station to be relocated to Cincinnati.
[e] Station to be relocated to Pittsburgh.

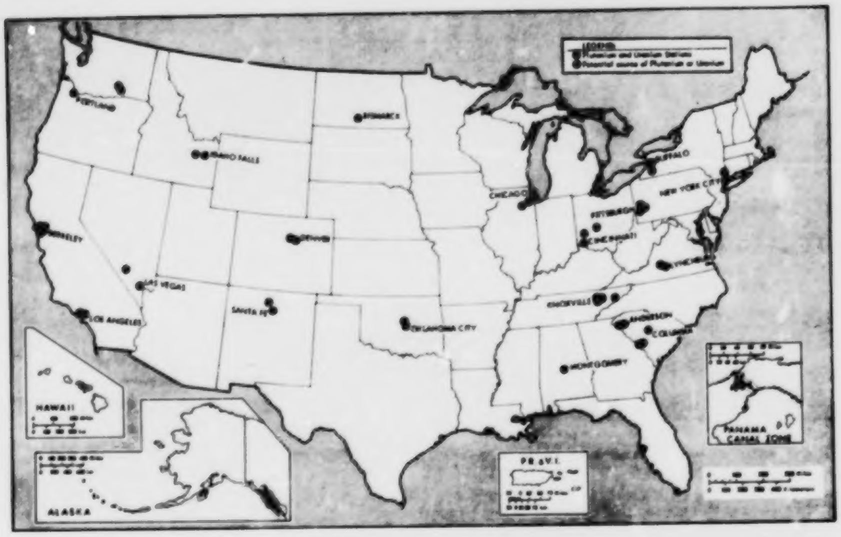
LEGEND
Plutonium and Uranium Stations
Potential source of Plutonium or Uranium
PORTLAND
BISMARCK
IDAHO FALLS
CHICAGO
BUFFALO
NEW YORK CITY
PITTSBURGH
CINCINNATI
BERKELEY
DENVER
LAS VEGAS
SANTA FE
LOS ANGELES
OKLAHOMA CITY
KNOXVILLE
ANDERSON
COLUMBIA
MONTGOMERY
HAWAII
ALASKA
PR & V.I.
PANAMA CANAL ZONE

Figure 1. ERAMS Plutonium and Uranium in Air Component sampling locations

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ERAMS Krypton-85 in Air Component, January-June 1973

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS) was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

Krypton-85 is a long-lived noble gas with a half life of 10.8 years. It is released into the atmosphere by nuclear reactor operations, fuel reprocessing, and nuclear detonations. Krypton-85 also occurs naturally in minor quantities primarily from the neutron capture of stable krypton-84 as well as spontaneous fission and neutron-induced fission of uranium. The monitoring of krypton-85 in the atmosphere has been conducted by the Eastern Environmental Radiation Facility (EERF), Montgomery, Ala., to identify and establish baseline levels and long-term trends, and these results have been published (*1,2*).

The krypton-85 in air component began operating on a routine basis in January 1973 with sample collections and analyses being performed on a semiannual basis from 12 sampling locations (figure 1). These locations were selected to provide atmospheric coverage of the United States with considerations being given to the proximity to fuel reprocessing plants, nuclear reactors, and wide geographic coverage. Dry compressed air samples were purchased from commercial air suppliers and analyzed for krypton-85 by the method of Cummings (*3*). The minimum detectable concentration for krypton-85 is approximately 2 pCi/m^3. The results for January–June 1973 are shown in table 1.

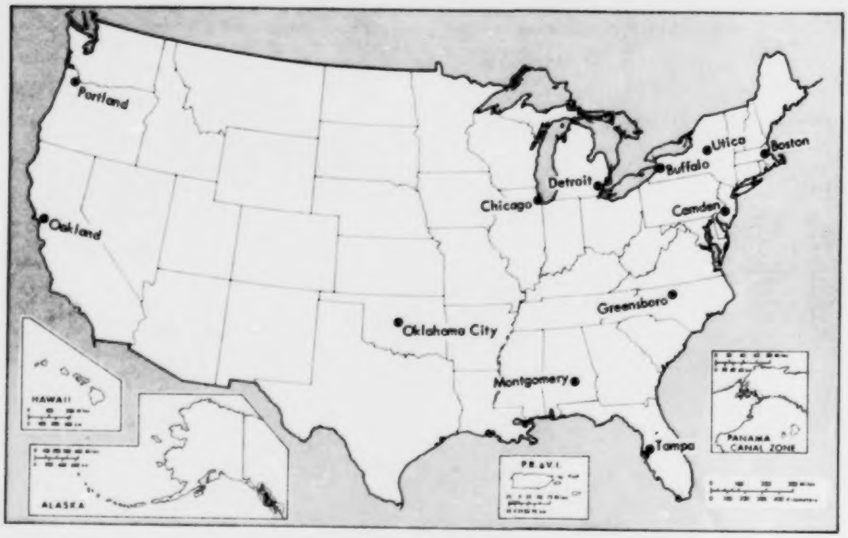
Portland
Oakland
Chicago
Detroit
Buffalo
Utica
Boston
Camden
Greensboro
Oklahoma City
Montgomery
Tampa
HAWAII
ALASKA
PR & V I
PANAMA CANAL ZONE

Figure 1. ERAMS Krypton-85 in Air Component sampling locations

Table 1. Krypton-85 in air, January-June 1973

Location		Krypton-85 concentration (pCi/m^3 at STP)[a]
Ala:	Montgomery	15.0
Calif:	Oakland	15.4
Fla:	Tampa	15.1
Ill:	Chicago	15.6
Mass:	Boston	14.3
Mich:	Detroit	14.9
N.J:	Camden	16.2
N.Y:	Buffalo	NS
	Utica	13.1
N.C:	Greensboro	15.8
Okla:	Oklahoma City	13.8
Oreg:	Portland	NS
Average		14.9

[a] Standard temperature and pressure.
NS, no sample.

REFERENCES

(*1*) SHUPING, R. E., C. R. PHILLIPS, and A. A. MOGHISSI. Krypton-85 levels in the environment determined from dated krypton gas samples. Radiol Health Data Rep 11:671–672 (December 1970).

(*2*) U.S. ENVIRONMENTAL PROTECTION AGENCY, EASTERN ENVIRONMENTAL RADIATION FACILITY. Krypton-85 in air, July 1970 to December 1972. Radiat Data Rep 15:133 (March 1974).

(*3*) CUMMINGS, S. L., R. L. SHEARIN, and C. R. PORTER. A rapid method of determining ^{85}Kr in environmental air samples. Proceedings of the International Symposium on Rapid Methods for Measurement of Radioactivity in the Environment (1971), pp. 163–169.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available from local AEC operations offices or from the National Technical Information Services at a nominal cost. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports.* Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in the individual reports have been converted from the format required by the AEC to that used by *Radiation Data and Reports.* The Environmental Protection Agency has not independently nor critically reviewed the data nor the conclusions derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Lawrence Livermore Laboratory and the National Reactor Testing Station.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Livermore Laboratory[2] January-December 1972

University of California
Livermore, Calif.

The Lawrence Livermore Laboratory (LLL) (figure 1) is located approximately 8 kilometers southeast of San Francisco in the Livermore Valley of California. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Prevailing winds are from the west and southwest during April through September. During the remainder of the year, winds from the northeast occur almost as frequently as those from the west and southwest. Annual rainfall is about 14 inches with most of the precipitation occurring during storms in the winter months. Surface water drainage from the valley is from east to west through various arroyos, with overflow near Sunol in the southwestern corner of the valley.

The Livermore Laboratory occupies a 2.5 square kilometer area approximately 5 kilometers east of the city of Livermore.

The laboratory plays an integral part in the nation's nuclear weapons development program and makes diversified researches into controlled thermonuclear reactions, industrial

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[2] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Lawrence Livermore Laboratory, January-December 1972.

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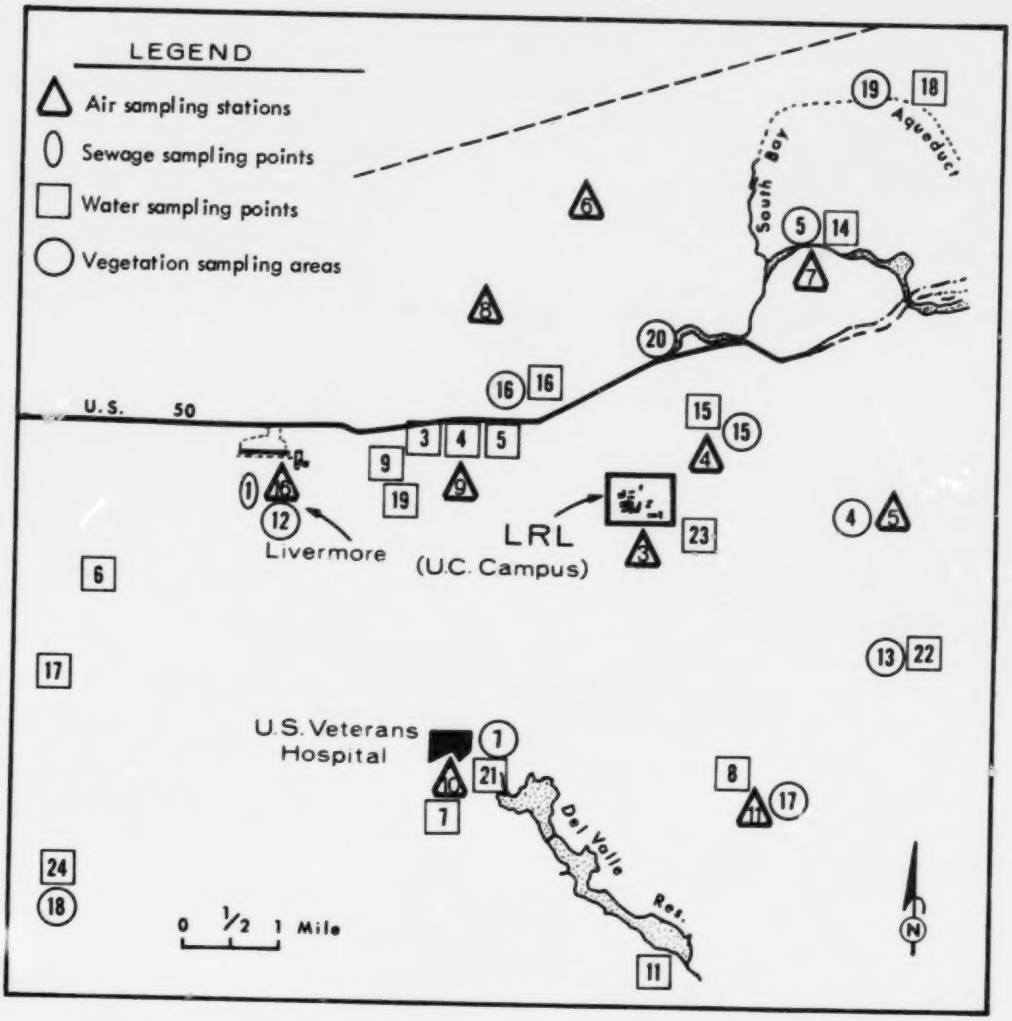
LEGEND
Air sampling stations
Sewage sampling points
Water sampling points
Vegetation sampling areas
U.S. 50
South Bay Aqueduct
Livermore
LRL
(U.C. Campus)
U.S. Veterans Hospital
Del Valle Res.
0 1/2 1 Mile
N
1
2
3
4
5
6
7
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24

Figure 1. Lawrence Livermore Laboratory offsite environmental sampling locations

applications of nuclear explosives, and the effects of radiation on the biosphere.

Much of the materials testing and high-explosive diagnostic work of the laboratory is carried on at Site 300, a 26 km^2 area located about 21 km southeast of Livermore in the sparsely populated hills of the Diablo range which separates the Livermore and San Joaquin Valleys.

In order to carry out these programs, the laboratory handles a variety of potentially hazardous radioactive materials. A strict effluent control program, which places maximum emphasis on controlling the effluents at the source, has been in continuous existence since the laboratory began operation. An environmental surveillance program is conducted to ensure that this effluent control program is indeed restricting the release of radioactivity from the Livermore Laboratory and Site 300 to concentrations below the standards set forth by the U.S. Atomic Energy Commission. This program employs techniques capable of detecting radioactivity at environmental background levels. The program includes the collection of airborne particulates, soil, water, sewer effluent, vegetation, and milk samples. These samples are analyzed for gross radioactivities as well as for the activity of specific radionuclides of interest. In addition, environmental background radiation is measured at numerous locations in the vicinity of the Livermore Laboratory by means of thermoluminescent detectors.

The results of the analyses are provided in this report. When appropriate, maximum, minimum, and average concentrations are given. Error limits, when included, reflect the uncertainties in the analyses at the 95 percent confidence level due to counting statistics. An attempt has been made to assess the impact resulting from the observed environmental activity levels of artificially and naturally produced radionuclides by calculating the whole body or critical organ doses that may be delivered to an adult by the various radionuclides of interest. Thus, one may compare the dose received from man's activity with that received from natural sources.

Atmospheric radioactivity

The concentrations of various airborne radioactive substances were measured at 16 air sampling stations situated throughout the Livermore Valley. Their locations are shown in figures 1 and 2. The six samplers located on the laboratory perimeter use 520 cm^2 Whatman 41 filters. The average sampling rate is 0.70 m^3/min. The remaining samplers, located offsite, use 230 cm^2 HV–70 (cellulose-asbestos) filters and operate at an average flow rate of 0.1 m^3/min. These air samplers are situated in such a manner that they provide a reasonable assurance that a significant release of airborne particulate radioactivity from the laboratory would be detected regardless of the local meteorology at the time of the release. Filters are changed twice a week during the summer months to avoid excessive mass loading and weekly during the balance of the year. An automatic radiation detection system with gas-flow proportional detectors was used to determine gross alpha and beta activities deposited on the filters after radon-thoron daughter decay. The filters are also assayed for gamma-emitting radionuclides by means of a specially designed Ge(Li) detector equipped with a Compton suppression system (*1*).

No gross alpha activity above the 1.0 fCi/m^3 detection limit was observed on the filters. The gross beta activities averaged over 6-month periods and the annual average radioactivities are shown for each sampling location in table 1, where they may be compared with the appropriate AEC standards. A significant fraction of the beta activities deposited on the filters is due to global fallout produced by nuclear weapons tests and by cosmic-ray interactions with the atmosphere. This is shown in table 2 which lists the activities of the more abundant gamma-emitting radionuclides in monthly composite samples collected by the six laboratory perimeter samplers. These data do not exhibit the typical spring increase in surface air radioactivity observed in previous years. The increased activity during January may possibly be due to a Chinese atmospheric nuclear weapon test detonated in January 1972.

These monthly composite samples were also subjected to plutonium and uranium analyses by dry ashing and complete dissolution of the filters and subsequent radiochemical separation of the elements. The plutonium was isolated by ion-exchange techniques and detected by alpha spectrometry. The isotopic uranium analyses were performed by mass spectrographic methods. The results are provided in table 3. Inspection of the data reveals that the relative activities of plutonium-238 and plutonium-239 approximate those normally observed in global fallout. The uranium-235 to uranium-238 ratios are somewhat lower than the natural uranium ($^{235}U/^{238}U = 7.25 \times 10^{-3}$). Airborne maximum concentrations are well below the guide levels for each isotope.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 2 and 3 are shown in table 4, indicate that manmade radiation provides a minor additional exposure, the largest fraction being from cerium-144 in global fallout (250 μrem). These lung doses were obtained by using the ICRP Lung Model (*2*), and making

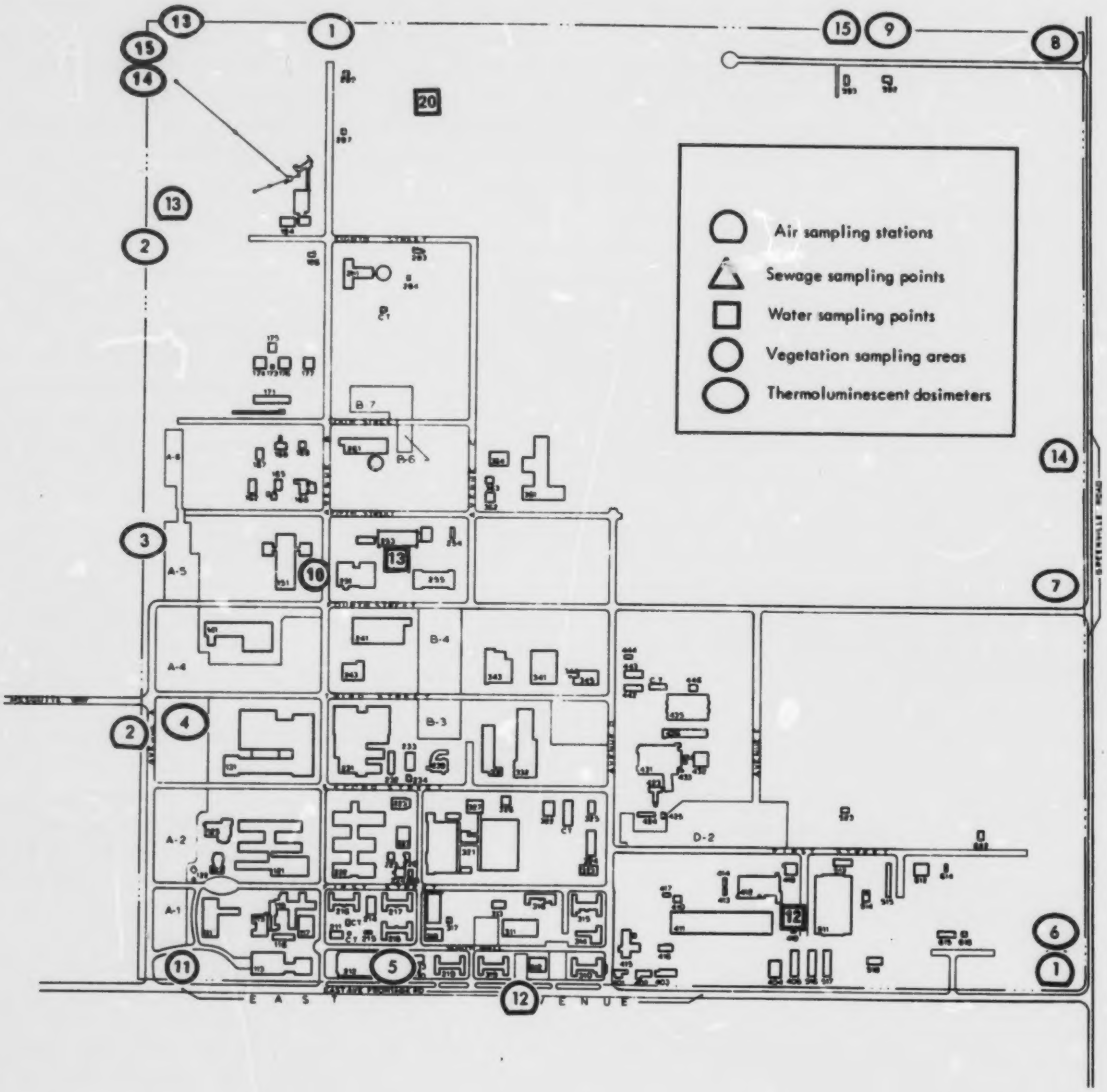
Air sampling stations
Sewage sampling points
Water sampling points
Vegetation sampling areas
Thermoluminescent dosimeters
A-1
A-2
A-4
A-5
A-6
B-3
B-4
B-6
B-7
D-2
EAST AVENUE
GREENVILLE ROAD

Figure 2. Lawrence Livermore Laboratory onsite environmental sampling locations

the following assumptions:

the radionuclides are present in an insoluble form,

the mean particle activity diameter is 1 micrometer, and

the activities of the radionuclides within the various body organs have obtained equilibrium.

We feel the first two assumptions are reasonable in view of the fact that the activities may be situated in insoluble silicate matrixes within particles that may range in size from 0.1 to several micrometers in diameter. This is the range usually observed in air pollution studies. Also, since global fallout has been with

Table 1. Airborne particulate radioactivity within the Livermore Valley, January-December 1972

Sampling location [a]	Gross beta radioactivity (fCi/m³)									Percent AEC standard [b]
	Number of samples	January-June 1972			Number of samples	July-December 1972			Annual average	
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	27	600 ±2%	19 ± 7%	96	33	130 ±4%	10 ±15%	47	72	7
2	33	350 ±5%	22 ± 7%	82	33	150 ±3%	12 ±20%	49	66	7
3	25	260 ±3%	13 ±14%	70	23	120 ±5%	10 ±32%	33	52	5
4	24	720 ±1%	23 ±13%	120	17	130 ±5%	18 ±20%	67	94	9
5	22	360 ±3%	17 ±16%	96	16	150 ±4%	6.9 ±46%	60	78	8
6	23	290 ±3%	8.2 ±19%	90	22	120 ±6%	5.7 ±55%	48	69	7
7	22	300 ±4%	5.9 ±49%	64	20	98 ±7%	9.7 ±33%	44	54	5
8	24	190 ±5%	7.1 ±37%	77	24	90 ±7%	8.4 ±39%	39	58	6
9	22	440 ±3%	16 ±12%	98	18	140 ±5%	16 ±22%	67	83	8
10	23	450 ±3%	14 ±13%	84	20	150 ±3%	8.4 ±39%	47	66	7
11	25	440 ±3%	8.3 ±19%	84	19	100 ±7%	4.9 ±63%	40	62	6
12	32	690 ±1%	11 ±16%	110	31	140 ±5%	9.2 ±14%	53	82	8
13	33	360 ±1%	19 ± 8%	110	33	150 ±3%	8.7 ±32%	55	83	8
14	33	680 ±1%	24 ± 7%	130	32	140 ±5%	16 ±20%	57	94	9
15	33	450 ±2%	21 ± 8%	120	33	160 ±4%	14 ±14%	56	88	9
16	25	360 ±3%	8.8 ±18%	82	32	110 ±6%	18 ±21%	50	66	7

[a] See figures 1 and 2 for sampling locations.
[b] The AEC standard is 1 pCi/m³.

Table 2. Results of gamma-ray spectral measurements of Livermore Laboratory perimeter air filters January-December 1972

Month (1972)	Concentration (fCi/m³)							
	Cerium-144	Cerium-141	Antimony-125	Beryllium-7	Ruthenium-103	Ruthenium-106	Cesium-137	Zirconium-95
January	28 ±10%	44 ± 6%	2.3 ± 64%	170 ± 8%	34 ± 6%	2.9 ± 34%	2.4 ±34%	21 ±16%
February	15 ± 8%	4.4 ± 20%	.40 ±100%	100 ± 8%	6.0 ±16%	.44 ± 86%	1.6 ± 4%	3.2 ± 2%
March	11 ± 6%	.75 ± 46%	.55 ± 54%	65 ±72%	.29 ±96%	.38 ± 46%	1.2 ±16%	.83 ±18%
April	19 ± 4%	14 ± 4%	1.4 ± 30%	120 ± 4%	6.4 ± 8%	.32 ± 64%	2.4 ±12%	19 ± 6%
May	31 ± 8%	30 ± 6%	2.1 ± 76%	150 ±10%	19 ±12%	.88 ± 42%	3.2 ±22%	44 ±10%
June	20 ± 6%	18 ± 4%	1.2 ± 44%	95 ± 6%	18 ± 6%	.52 ± 56%	2.2 ±16%	26 ± 8%
July	17 ± 6%	14 ± 3%	1.5 ± 33%	98 ± 5%	17 ± 5%	.80 ± 35%	1.9 ±16%	15 ± 8%
August	12 ± 6%	5.7 ± 8%	.68 ± 54%	110 ± 5%	9.4 ± 8%	4.0 ± 36%	1.7 ±16%	6.3 ±16%
September	10 ± 7%	2.9 ± 10%	.62 ± 60%	150 ± 4%	4.4 ±10%	.57 ± 35%	1.8 ±14%	4.2 ±18%
October	8.1 ±11%	.90 ± 42%	.64 ± 84%	250 ± 4%	2.2 ±20%	.54 ± 52%	1.5 ±21%	3.5 ±26%
November	3.5 ±14%	.76 ± 57%	.61 ± 45%	170 ± 4%	.87 ±45%	.14 ±100%	.68 ±24%	.96 ±18%
December	2.4 ±35%	.17 ±100%	.41 ± 45%	120 ± 6%	.29 ±89%	.18 ±100%	.63 ±46%	.49 ±29%
Annual average	15	11	1.0	130	9.8	0.97	1.8	14
AEC standard [a]	2×10⁵	5×10⁶	9×10⁵	4×10⁷	3×10⁶	2×10⁵	5×10⁵	1×10⁶
Percent AEC standard	0.0074	0.00022	0.00011	0.00033	0.00033	0.00049	0.00035	0.0014

[a] Assumes the activity is in an insoluble form.

us for upwards of two decades, the third assumption should be valid for most radionuclides since their half-lives in the lung are short relative to the long exposure time.

Soil

The laboratory's soil sampling program was upgraded during 1971 to include a determination of distribution of various radionuclides that have been deposited within the Livermore Valley as a result of global fallout from atmospheric weapons tests as well as from possible laboratory effluents. A core sampling method was used to obtain the soil samples at various depths down to 25 cm. Each sample was collected over a surface area of about 300 cm² by combining a minimum of 10 separate cores obtained over an approximate 250 m² area.

The samples were thoroughly dried and homogenized before undergoing analyses for the radionuclides of interest. One-hundred-

Table 3. Plutonium and uranium concentrations in air at Livermore Laboratory perimeter, January-December 1972

Month (1972)	Activity (aCi/m^3)		^{238}Pu/^{239}Pu	Mass (pg/m^3)		^{235}U/^{238}U[a]
	^{238}Pu	^{239}Pu		^{238}Pu	^{239}Pu	
January	1.4 ±19%	25 ± 7%	0.056	0.38 ±2%	65 ±4%	0.0058
February	1.5 ±21%	24 ± 8%	.062	.41 ±1%	130 ±2%	.0032
March	1.6 ±10%	17 ± 6%	.094	.27 ±2%	53 ±3%	.0051
April	3.5 ± 5%	35 ± 4%	.10	.33 ±2%	48 ±3%	.0069
May	4.2 ± 6%	45 ± 3%	.093	.63 ±2%	89 ±3%	.0071
June	3.3 ±12%	39 ± 6%	.085	.92 ±2%	130 ±3%	.0071
July	2.4 ±12%	36 ± 6%	.067	1.1 ±1%	130 ±2%	.0085
August	3.8 ± 9%	58 ± 6%	.067	1.4 ±1%	220 ±2%	.0064
September	3.9 ±10%	48 ± 6%	.079	1.6 ±1%	250 ±2%	.0064
October	2.4 ±16%	33 ± 7%	.073	.34 ±1%	54 ±2%	.0063
November	.51 ±27%	11 ± 9%	.046	.16 ±1%	29 ±2%	.0055
December	1.2 ±25%	12 ±10%	.10	.019 ±1%	36 ±2%	.0058
Annual average	2.5	32		0.63	100	
AEC standard[b]	1.0×10^6	1.0×10^6		1.9×10^6	1.5×10^7	
Percent of AEC standard	0.00025	0.0032		0.000033	0.00067	

[a] The ^{235}U/^{238}U ratio in natural uranium is 0.00725.

[b] Assumes the activity is in an insoluble form.

Table 4. Average annual integrated inhalation radiation doses at air concentrations shown in tables 2 and 3

Radionuclide	Calculated annual lung dose (μrem)
Cerium-144	250
Cerium-141	26
Antimony-125	34
Beryllium-7	27
Ruthenium-103	34
Ruthenium-106	17
Cesium-137	9.2
Zirconium-95	91
Plutonium-238	1.8
Plutonium-239	22
Uranium-235	2.0
Uranium-238	44

gram aliquots of samples were subjected to complete acid dissolution for the analysis of plutonium-238, plutonium-239, and strontium-90 by radiochemical techniques. Gamma spectral analyses were made by placing approximately 300 grams of soil on a Ge(Li) detector equipped with a Compton suppression system. These analyses provided quantitative data regarding the concentrations of artificially produced cesium-137 and the naturally occurring potassium-40, lead-212, and bismuth-214 activities.

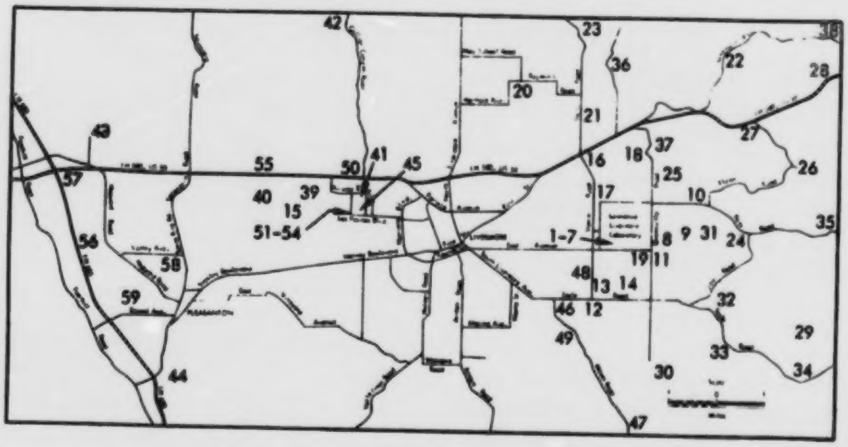

Figure 3. Livermore Valley soil sampling locations

Table 5. Activity levels of various radionuclides in soil, Lawrence Livermore, January-December 1972

Sampling location	Depth (cm)	Concentration (fCi/g)		
		Plutonium-238	Plutonium-239	Strontium-90
43	0-24		5.5 ± 5%	
44	0- 1		3.0 ±10%	
	0-24		3.2 ± 5%	
45	0- 5		360 ± 5%	68 ± 11%
	5-10		12 ± 5%	5.9 ± 86%
	10-15		9.0 ± 5%	11 ±118%
	15-25		1.2 ± 5%	11 ± 94%
46	0-25		2.6 ± 5%	67 ± 5%
47	0-25		1.8 ± 6%	61 ± 9%
48	0-25		2.2 ± 7%	62 ± 6%
49	0-25		2.5 ± 5%	68 ± 5%
50	0-25	.18 ±14%	2.8 ± 4%	92 ± 4%
51	0- 1	1.2 ± 8%	30 ± 4%	35 ± 15%
	1-25	2.6 ± 7%	100 ± 3%	13 ± 34%
52	0- 1	.72 ± 8%	5.9 ± 8%	30 ± 18%
	1-25	3.5 ± 9%	98 ± 5%	17 ± 23%
53	0- 1	1.8 ± 8%	16 ± 4%	
	1-25	13 ± 4%	220 ± 3%	29 ± 18%
54	0- 1	1.6 ± 7%	18 ± 4%	
	1-25	14 ± 5%	420 ± 4%	
55	0-30	.14 ±15%	3.5 ± 4%	
56	0-25	.59 ±11%	9.3 ± 4%	57 ± 8%
57	0-25	.14 ±15%	2.1 ± 4%	
58	0-25	.23 ±12%	7.6 ± 3%	
59	0-25	.14 ±14%	2.6 ± 4%	66 ± 7%
60	0-25	.10 ±30%	4.8 ± 8%	7.1 ± 39%
61	0-25	.91 ±20%	29 ± 7%	
62	0-25	.40 ±18%	15 ± 6%	18 ± 23%
63	0- 1	.59 ±17%	14 ± 7%	260 ± 7%
	1- 5	.45 ±19%	8.9 ± 7%	170 ± 6%
	5-10	.36 ±15%	12 ± 5%	140 ± 4%
	10-15	.18 ±19%	7.1 ± 6%	95 ± 5%
	15-20	.091 ±24%	2.7 ± 5%	43 ± 9%
	20-25	.091 ±24%	4.0 ± 7%	30 ± 12%
64	0-25	.30 ±28%	4.3 ±10%	
65	0-25	.30 ±24%	6.6 ± 8%	110 ± 14%
66	0- 1	.40 ±24%	8.5 ± 8%	93 ± 6%
	1- 5	.20 ±27%	5.4 ± 9%	81 ± 6%
	5-10	.20 ±26%	8.3 ± 7%	86 ± 7%
	10-15	.10 ±26%	3.4 ± 7%	60 ± 8%
	15-20		1.9 ±13%	16 ± 18%
	20-25		1.6 ±13%	7.3 ± 7%
67	0-25	.22 ±30%	2.6 ±10%	32 ± 9%
68	0- 1	.23 ±28%	5.3 ± 8%	
	1- 5	.32 ±23%	5.7 ± 8%	
	5-10	.23 ±26%	4.9 ± 8%	
	10-15	.045 ±40%	3.5 ± 9%	
	15-20		1.4 ±22%	
	20-25		1.3 ±19%	
69	0-25	1.0 ±17%	9.6 ± 6%	
70	0-25	.60 ±19%	7.2 ± 6%	49 ± 5%
71	0-25	.20 ± 7%	15 ± 7%	
72	0-25	.40 ±17%	6.0 ± 7%	
73	0-25	.30 ±28%	6.1 ± 9%	42 ± 9%
74	0-25		1.9 ±10%	53 ± 10%
75	0-25		2.6 ± 9%	
76	0-25		2.5 ± 9%	
77	0-25		2.3 ± 9%	
78	0-25	.20 ±18%	1.5 ±10%	
79	0-25		6.3 ± 7%	19 ± 15%
80	0-25		3.6 ±10%	
81	0-25	.45 ±37%	1.9 ±11%	
82	0-20		3.4 ± 9%	95 ± 4%
83	0-25		1.1 ±12%	
84	0- 1		3.1 ±14%	
	1- 5		2.4 ±13%	
	5-10		1.6 ±16%	
	10-15		2.4 ±16%	
	15-20		1.1 ±11%	
	20-25		2.0 ±10%	
85	0-25		1.7 ± 6%	
86	0-25		.84 ±14%	
87	0-25		1.6 ±13%	53 ± 12%
88	0-20		4.9 ± 8%	
89	0-25		2.3 ± 9%	
90	0-25		2.3 ±10%	
91	0-25		1.7 ±13%	
92	0-20		1.1 ±10%	
93	0-25		.97 ±12%	
94	0-25		2.3 ± 9%	
95	0-25		2.2 ± 9%	
96	0-30		4.3 ± 8%	42 ± 10%
97	0-30	.40 ± 7%	9.1 ± 7%	35 ± 15%
98	0-30		2.8 ±11%	41 ± 20%
99	0-30		3.6 ±10%	55 ± 17%

Table 6. Activity levels of various gamma-emitting radionuclides in soil January-December 1972

Sampling location	Depth (cm)	Concentration (dry weight) (fCi/g)			Potassium-40 (pCi/g dry weight)
		Cesium-137	Bismuth-214	Lead-212	
43	0- 1	580 ± 16%	450 ± 42%	530 ± 26%	11 ± 22%
	0-25	230 ± 40%	280 ± 57%	570 ± 22%	7.9 ± 24%
44	0- 1	320 ± 18%	240 ± 79%	450 ± 29%	3.5 ± 23%
	0-25	71 ± 64%	280 ± 50%	490 ± 22%	10 ± 20%
45	0- 5	310 ± 20%	440 ± 36%	650 ± 18%	9.9 ± 10%
	5-10	42 ± 80%	440 ± 36%	660 ± 17%	9.5 ± 20%
	10-15	58 ± 62%	500 ± 34%	710 ± 17%	9.6 ± 20%
	15-25	46 ± 71%	490 ± 35%	700 ± 17%	12 ± 18%
46	0- 1	94 ± 41%	430 ± 40%	510 ± 23%	8.1 ± 24%
	0-25	190 ± 29%	450 ± 40%	660 ± 19%	9.4 ± 17%
47	0-25	110 ± 43%	400 ± 44%	550 ± 22%	8.8 ± 17%
48	0-25	30 ± 90%	520 ± 29%	710 ± 15%	14 ± 14%
49	0- 1	680 ± 16%	300 ± 58%	480 ± 26%	5.6 ± 22%
	0-25	130 ± 32%	290 ± 55%	460 ± 25%	5.2 ± 20%
50	0-25	40 ± 98%	380 ± 42%	590 ± 19%	7.5 ± 22%
51	0- 1	110 ± 36%	390 ± 38%	640 ± 16%	9.5 ± 18%
	1-25	ND	330 ± 51%	580 ± 21%	11 ± 20%
52	0- 1	55 ± 74%	540 ± 31%	670 ± 18%	7.9 ± 24%
	1-25	24 ± 74%	540 ± 29%	670 ± 16%	7.9 ± 24%
53	0- 1	55 ± 62%	450 ± 32%	600 ± 17%	11 ± 16%
	1-25	240 ± 24%	630 ± 26%	640 ± 18%	13 ± 18%
54	0- 1	130 ± 34%	540 ± 32%	720 ± 17%	12 ± 20%
	1-25	28 ± 100%	540 ± 29%	730 ± 15%	14 ± 12%
55	0- 1	250 ± 20%	570 ± 27%	490 ± 22%	7.7 ± 16%
	1-25	73 ± 62%	290 ± 46%	530 ± 21%	10 ± 18%
56	0- 1	780 ± 14%	310 ± 64%	470 ± 36%	9.4 ± 22%
	1-25	100 ± 48%	440 ± 44%	720 ± 18%	10 ± 16%
57	0- 1	94 ± 44%	550 ± 32%	570 ± 21%	12 ± 13%
	1-25	20 ± 92%	430 ± 42%	710 ± 18%	12 ± 14%
58	0- 1	280 ± 18%	350 ± 46%	520 ± 22%	12 ± 12%
	1-25	94 ± 38%	410 ± 35%	570 ± 18%	9.2 ± 18%
59	0- 1	170 ± 26%	370 ± 43%	660 ± 16%	10 ± 13%
	1-25	83 ± 52%	390 ± 42%	540 ± 21%	10 ± 22%
60	0- 1	11 ± 100%	520 ± 30%	540 ± 20%	10 ± 14%
	1-25	63 ± 100%	390 ± 41%	700 ± 16%	9.6 ± 14%
61	0- 1	34 ± 100%	750 ± 30%	980 ± 15%	12 ± 16%
	1-25	57 ± 38%	730 ± 22%	900 ± 12%	12 ± 11%
62	0- 1	130 ± 30%	490 ± 32%	580 ± 19%	12 ± 12%
	1-25	52 ± 72%	350 ± 46%	580 ± 19%	8.3 ± 17%
63	0- 1	370 ± 19%	580 ± 30%	490 ± 24%	9.8 ± 16%
	1- 5	460 ± 18%	780 ± 28%	890 ± 17%	14 ± 15%
	5-10	360 ± 21%	640 ± 35%	770 ± 20%	15 ± 15%
	10-15	200 ± 27%	620 ± 32%	820 ± 17%	14 ± 12%
	15-20	36 ± 100%	640 ± 30%	860 ± 15%	14 ± 12%
63	20-25	28 ± 100%	580 ± 37%	790 ± 19%	12 ± 14%
64	0- 1	770 ± 10%	450 ± 34%	580 ± 18%	11 ± 12%
	1-25	130 ± 34%	450 ± 36%	500 ± 22%	10 ± 15%
65	0- 1	380 ± 16%	550 ± 29%	570 ± 19%	10 ± 18%
	1-25	190 ± 26%	390 ± 37%	540 ± 19%	11 ± 10%
66	0- 1	230 ± 24%	290 ± 54%	530 ± 21%	8.3 ± 18%
	1- 5	180 ± 26%	480 ± 32%	540 ± 19%	11 ± 12%
	5-10	210 ± 24%	440 ± 34%	530 ± 20%	12 ± 12%
	10-15	89 ± 36%	440 ± 29%	450 ± 20%	10 ± 10%
	15-20	19 ± 88%	430 ± 29%	500 ± 17%	11 ± 10%
	20-25	51 ± 62%	480 ± 31%	510 ± 19%	12 ± 12%
67	0- 1	720 ± 10%	390 ± 36%	430 ± 23%	8.0 ± 18%
	1-25	36 ± 73%	260 ± 47%	350 ± 23%	8.1 ± 12%
68	0- 1	290 ± 20%	460 ± 34%	490 ± 22%	7.3 ± 16%
	1- 5	300 ± 18%	530 ± 29%	570 ± 18%	8.2 ± 14%
	5-10	290 ± 18%	480 ± 31%	520 ± 19%	.74 ± 14%
	10-15	90 ± 38%	470 ± 30%	580 ± 17%	7.5 ± 14%
	15-20	43 ± 66%	570 ± 23%	560 ± 16%	8.0 ± 8%
	20-25	21 ± 58%	560 ± 23%	520 ± 17%	8.8 ± 12%
69	0- 1	270 ± 13%	300 ± 54%	530 ± 21%	8.6 ± 18%
	1-25	110 ± 34%	440 ± 33%	540 ± 19%	8.0 ± 15%
70	0- 1	570 ± 12%	480 ± 34%	470 ± 23%	9.9 ± 14%
	1-25	100 ± 40%	260 ± 58%	490 ± 21%	9.6 ± 15%
71	0- 1	60 ± 61%	560 ± 30%	720 ± 16%	10 ± 14%
	1-25	56 ± 61%	570 ± 28%	660 ± 16%	11 ± 13%
72	0- 1	580 ± 16%	600 ± 36%	700 ± 21%	11 ± 17%
	1-25	90 ± 41%	710 ± 25%	810 ± 15%	12 ± 12%
73	0- 1	410 ± 17%	650 ± 31%	780 ± 18%	11 ± 15%
	1-25	69 ± 60%	850 ± 22%	890 ± 14%	11 ± 14%
74	0- 1	150 ± 15%	470 ± 34%	530 ± 20%	13 ± 13%
	1-25	63 ± 49%	510 ± 31%	430 ± 25%	11 ± 12%
75	0- 1	330 ± 21%	660 ± 30%	710 ± 18%	10 ± 17%
	1-25	110 ± 45%	360 ± 49%	820 ± 15%	11 ± 15%
76	0- 1	540 ± 12%	390 ± 41%	670 ± 17%	11 ± 13%
	1-25	130 ± 37%	470 ± 39%	660 ± 18%	11 ± 14%
77	0- 1	260 ± 24%	350 ± 52%	470 ± 27%	7.4 ± 20%
	1-25	120 ± 40%	450 ± 39%	500 ± 24%	8.8 ± 17%
78	0-25	ND	450 ± 33%	460 ± 22%	7.1 ± 18%
79	0- 1	62 ± 58%	580 ± 28%	570 ± 20%	11 ± 13%
	1-25	47 ± 70%	580 ± 28%	620 ± 18%	12 ± 12%
80	0- 1	300 ± 22%	480 ±40%	540 ± 25%	13 ± 14%
	1-20	120 ± 41%	690 ± 28%	580 ± 22%	11 ± 16%

See footnotes at end of table.

Table 6. Activity levels of various gamma emitting radionuclides in soil January-December 1972—continued

Sampling location	Depth (cm)	Concentration (dry weight) (fCi/g)			Potassium-40 (pCi/g dry weight)
		Cesium-137	Bismuth-214	Lead-212	
81	0- 1	310 ± 16%	500 ± 31%	580 ± 18%	12 ± 12%
	1- 5	210 ± 22%	420 ± 35%	600 ± 19%	15 ± 10%
	5-10	150 ± 20%	490 ± 25%	590 ± 14%	15 ± 8%
	10-15	28 ± 82%	520 ± 23%	620 ± 14%	14 ± 8%
	15-20	22 ± 94%	520 ± 23%	620 ± 14%	14 ± 8%
	20-25	ND	430 ± 30%	560 ± 16%	13 ± 10%
82	0- 1	250 ± 19%	430 ± 38%	650 ± 17%	10 ± 13%
	1-20	180 ± 29%	530 ± 34%	630 ± 20%	8.9 ± 17%
83	0- 1	180 ± 32%	400 ± 50%	520 ± 27%	8.5 ± 19%
	1-25	200 ± 23%	310 ± 50%	530 ± 21%	9.3 ± 14%
84	0- 1	120 ± 32%	390 ± 38%	480 ± 22%	7.9 ± 16%
	1- 5	170 ± 22%	440 ± 32%	450 ± 21%	6.7 ± 15%
	5-10	91 ± 35%	390 ± 33%	500 ± 18%	8.6 ± 13%
	10-15	85 ± 40%	360 ± 38%	430 ± 23%	7.8 ± 15%
	15-20	50 ± 60%	440 ± 31%	480 ± 19%	7.9 ± 14%
	20-25	71 ± 52%	310 ± 48%	500 ± 21%	7.9 ± 16%
85	0- 1	400 ± 17%	510 ± 37%	580 ± 23%	11 ± 14%
	1-25	130 ± 30%	600 ± 27%	620 ± 18%	12 ± 12%
86	0- 1	73 ± 57%	500 ± 35%	590 ± 19%	12 ± 14%
	1-25	64 ± 58%	580 ± 29%	470 ± 23%	11 ± 17%
87	0- 1	110 ± 38%	500 ± 33%	580 ± 20%	9.2 ± 15%
	1-25	82 ± 42%	570 ± 27%	620 ± 17%	10 ± 13%
88	0-20	260 ± 19%	630 ± 25%	690 ± 15%	10 ± 13%
89	0- 1	170 ± 25%	410 ± 36%	500 ± 20%	8.8 ± 14%
	1- 5	120 ± 27%	410 ± 30%	480 ± 18%	8.5 ± 13%
	5-10	42 ± 80%	580 ± 29%	660 ± 17%	11 ± 13%
	10-15	53 ± 73%	370 ± 47%	470 ± 26%	8.7 ± 17%
	15-20	140 ± 36%	740 ± 27%	590 ± 21%	12 ± 15%
	20-25	110 ± 30%	310 ± 40%	370 ± 24%	8.0 ± 14%
90	0- 1	300 ± 18%	350 ± 44%	550 ± 20%	8.6 ± 15%
	1-25	78 ± 40%	390 ± 32%	430 ± 21%	7.5 ± 14%
91	0- 1	100 ± 36%	540 ± 25%	650 ± 16%	13 ± 11%
	1-25	110 ± 35%	590 ± 27%	710 ± 15%	15 ± 10%
92	0- 1	120 ± 41%	570 ± 32%	650 ± 19%	8.4 ± 18%
	1-20	70 ± 62%	560 ± 33%	590 ± 21%	7.5 ± 19%
93	0- 1	68 ± 52%	630 ± 26%	560 ± 20%	11 ± 13%
	1-25	50 ± 77%	510 ± 35%	630 ± 19%	11 ± 14%
94	0- 1	1000 ± 11%	350 ± 56%	650 ± 22%	8.3 ± 20%
	1-25	93 ± 38%	440 ± 33%	620 ± 17%	6.6 ± 17%
95	0- 1	1200 ± 8%	450 ± 25%	370 ± 41%	9.6 ± 14%
	1-25	85 ± 50%	510 ± 21%	330 ± 48%	8.0 ± 18%

ND, nondetectable

The results of the analyses are provided in tables 5 and 6, and the sampling locations are shown in figure 3. The depth profile studies at sampling locations 63, 66, 68, and 84 indicate the artificially produced radionuclides to penetrate appreciably into the soil, probably as a result of leaching or mechanical mixing. As expected, the natural activities of potassium-40, lead-212, and bismuth-214 seem to be distributed fairly homogeneously with depth. Inspection of the data indicates that most of the activity in the soil is due to the naturally occurring radionuclides. On a concentration basis, the potassium-40 exhibits the highest values with lead-212 and bismuth-214 showing lesser values, but in general greater than those of the artificially produced radionuclides. Bismuth-214 and lead-212 are daughter products of uranium-238 and thorium-232, respectively.

The resulting deposition values of plutonium-238, plutonium-239, strontium-90 and cesium-137 are shown in table 7. Most of the plutonium-239 deposition levels are of the order of 1 nCi/m^2, and have resulted from global fallout, but some locations indicate values that are appreciably higher. For instance, elevated levels were exhibited by samples collected from the holding pond at the Livermore Sewage Treatment Plant represented by locations 45 and 51 through 54. These values have resulted from routine and accidental releases of small amounts of plutonium over long time periods through the sanitary sewer system which carries the laboratory's biological and industrial effluents to the Livermore Sewage Treatment Plant.

The median deposition level of strontium-90 within the Livermore Valley is 20 nCi/m^2. This

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Table 7. Deposition levels of various radionuclides in soil, Lawrence Livermore, January-December 1972

Sampling location	Concentration (nCi/m²)			
	Plutonium-238	Plutonium-239	Strontium-90	Cesium-137
43		1.9		80
44		1.2		20
45		27	6.7	28
46		.91	23	67
47		.65	22	
48		.76	22	11
49		.87	24	53
50	0.063	.98	33	14
51	.88	34	5.1	
52	1.2	33	6.4	9.2
53	4.6	78		91
54	5.4	160		11
55	.057	1.5	25	29
56	.19	3.0		39
57	.044	.68		7.5
58	.079	2.7		36
59	.047	.90	24	30
60	.050	1.8	2.7	
61	.32	11		
62	.20	5.5	6.8	21
63	.068	2.0	29	47
64	.10	1.6		58
65	.10	2.8	45	83
66	.051	1.9	22	50
67	.10	1.3	15	30
68	.047	1.4		62
69	.20	3.6		43
70	.10	2.9	20	43
71	.090	5.9		22
72	.15	2.2		39
73	.12	2.2	15	28
74		.74	21	27
75		.92		41
76		.91		54
77		.81		44
78	.090	.62		
79		2.2	6.7	17
80		.99		36
81	.020	.78		29
82		.90	26	48
83		.38		70
84		.76		32
85		.61		48
86		.34		26
87		.58	20	33
88		1.5		78
89		1.0		36
90		.97		33
91		.64		42
92		.31		27
93		.36		19
94		.87		49
95		.87		49
96		1.9	19	
97	.18	3.2	16	
98		1.3	18	
99		1.6	25	

is about a factor of 4 less than the global fallout levels measured at many locations throughout the United States by the U.S. AEC Health and Safety Laboratory. Thus, the strontium-90 and cesium-137 deposition levels may readily be accounted for as being due to global fallout rather than laboratory contributed.

Environmental radiation levels due to the gamma-emitting radionuclides distributed in the soil may be calculated from table 7 using the data of Beck et al (*3*). The median exposure rate due to the cesium-137 activity found in Livermore Valley soils is approximately 0.1 μR/h (0.88 mR/yr). The total natural terrestrial exposure rate was also calculated for each sample from the potassium-40, bismuth-214 (uranium series) and lead-212 (thorium series) soil activities. These calculations showed a median exposure rate of 4.4 μR/h (38 mR/yr) with a range from 2.8 to 6.4 μR/h (25 to 56 mR/yr). When the approximately 4 μR/hr exposure rate from local cosmic radiation is added to these calculated terrestrial exposure rates, the totals are in good agreement with those obtained by TLD measurements.

Thus, the natural contribution to the exposure rate due to gamma emitters in the soil is far greater than that due to the artificially produced radionuclides. To determine the environmental impact due to the elevated plutonium deposition levels is very difficult. For these particular sites, the primary concern to man is that due to resuspension of the plutonium and subsequent inhalation. Since resuspension factors vary many orders of magnitude, it is difficult to calculate a meaningful expected airborne concentration. However, we anticipate that these airborne concentrations will be within the range of background levels.

Sewer effluent

The low level radioactive wastes from the laboratory are discharged into the City of Livermore sanitary sewer system. This effluent is processed at the Livermore Sewage Treatment Plant where the liquid and sludge are separated on entering the plant. The sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned, and the remaining sludge is released to large sludge ponds and retained for subsequent use as a soil conditioner. The purified water is used for irrigating the Livermore Golf Course and nearby agricultural land; the excess is discharged into the Los Positas Arroyo.

Weekly samples were collected from each digester, the aeration tank and the liquid effluent discharged from the plant in order to determine if any significant buildup of radioactivity occurred within the plant. After complete dissolution (using wet oxidation), the gross alpha and beta activities associated with these samples were determined by gas proportional counting. Tritium analyses were performed by subjecting 1 ml of each sample to direct liquid scintillation counting. In addition, a monthly composite sample of the effluent was analyzed for strontium-90 and plutonium-239 by radiochemical separation followed by beta and alpha counting, respectively. The concentrations observed during 1972 averaged over 1 month periods are given in tables 8, 9, and 10. Most of the gross alpha and gross beta activities are associated with the sludge present in the effluent. Thus, samples obtained from the digesters show the highest activities with the expected attendant decrease in activity as the relatively purified liquid passes through the aeration tank and is finally released from the plant.

Water

Water samples were collected from various locations in the Livermore Valley. These samples were analyzed for gross alpha and gross beta activities by techniques similar to those used for sewage effluent samples. No sample showed an alpha activity above the limit of sensitivity of 1.2 pCi/liter. Quarterly averages for beta activities are given in table 11. Loca-

Table 8. Livermore sewage treatment plant sampling results, 1972

Month (1972)	Gross alpha activity (pCi/liter)							
	Number of samples	Digesters			Number of samples	Aeration tank		
		Maximum	Minimum	Average		Maximum	Minimum	Average
January	8	690 ±26%	280 ± 42%	430	4	79 ±28%	35 ±46%	48
February	10	430 ±38%	81 ±54%	190	5	87 ±29%	52 ±43%	66
March	8	460 ±32%	150 ± 42%	280	4	170 ±20%	46 ±36%	98
April	8	360 ±32%	160 ± 35%	240	4	120 ±24%	51 ±34%	80
May	10	550 ±36%	160 ± 37%	250	5	120 ±24%	70 ±34%	86
June	8	1 500 ±30%	230 ± 35%	390	4	67 ±30%	13 ±30%	35
July	7	390 ±32%	88 ± 54%	220	3	70 ±33%	41 ±39%	51
August	10	470 ±28%	170 ± 37%	280	5	83 ±31%	58 ±39%	71
September	8	400 ±28%	170 ± 53%	330	4	56 ±31%	36 ±52%	43
October	10	290 ±35%	13 ±100%	200	5	61 ±34%	28 ±45%	50
November	8	740 ±30%	120 ± 60%	430	4	83 ±29%	58 ±36%	67
December	4	400 ±32%	260 ± 38%	330	2	92 ±28%	61 ±32%	77

Table 9. Livermore sewage treatment plant sampling results, January-December 1972

Month (1972)	Gross beta activity (pCi/liter)												
	Number of samples	Digesters			Number of samples	Aeration tank			Number of samples	Effluent			Percent AEC standard[a]
		Maximum	Minimum	Average		Maximum	Minimum	Average		Maximum	Minimum	Average	
January	8	2 300 ±10%	300 ±12%	800	4	61 ±6%	43 ± 8%	54	9	20 ±34%	8.5 ± 67%	14	14
February	10	670 ± 9%	220 ±14%	380	5	63 ±6%	40 ± 8%	53	11	18 ±37%	11 ± 56%	15	15
March	8	920 ± 7%	230 ±16%	420	4	81 ±5%	46 ± 7%	59	11	35 ±23%	7.2 ±100%	16	16
April	8	610 ±13%	270 ±13%	380	4	73 ±6%	55 ± 7%	64	11	20 ±33%	8.9 ±100%	14	14
May	10	750 ±15%	200 ±18%	390	5	66 ±6%	51 ± 7%	57	10	20 ±33%	7.4 ±100%	13	13
June	8	39 000 ± 1%	280 ±15%	10 000	4	53 ±7%	20 ±12%	40	8	15 ±42%	8.2 ±100%	11	11
July	6	4 000 ± 3%	210 ±18%	930	3	37 ±8%	36 ± 9%	37	11	19 ±38%	8.0 ± 71%	14	14
August	10	310 ±16%	230 ±19%	260	5	47 ±7%	36 ± 9%	41	10	17 ±41%	9.5 ± 64%	13	13
September	8	330 ±15%	240 ±16%	290	4	57 ±7%	41 ± 8%	47	12	21 ±33%	7.8 ±100%	13	13
October	10	330 ±14%	70 ±20%	230	5	60 ±6%	41 ± 8%	52	6	23 ±32%	11 ± 57%	16	16
November	8	8 000 ± 3%	250 ±17%	1 400	4	49 ±7%	44 ± 8%	46	11	61 ±17%	8.3 ±100%	14	14
December	4	400 ±14%	260 ±16%	320	2	52 ±7%	41 ± 8%	46	5	25 ±30%	8.6 ±100%	15	15

[a] AEC standard-100 pCi/liter.

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Table 10. Livermore sewage treatment plant sampling results, January-December 1972

Month (1972)	Number of samples	Effluent (pCi/liter)							
		Tritium				Strontium-90		Plutonium-239	
		Maximum	Minimum	Average	Percent AEC standard[a]	Average	Percent AEC standard[b]	Average	Percent AEC standard[c]
January	9	3.0 ±33%	1.2 ±100%	1.5	0.050	(d)		(d)	
February	11	3.7 ±28%	1.2 ±100%	1.5	.050	1.2 ± 54%	0.40	(d)	
March	11	3.8 ±27%	1.2 ±100%	1.5	.050	.43 ± 54%	.14	1.0	0.020
April	11	63 ± 2%	1.2 ±100%	8.9	.30	.42 ± 72%	.14	.14	.0030
May	10	1.9 ±49%	1.2 ±100%	1.3	.040	.37 ±100%	.12	.11	.0020
June	8	7.4 ±15%	1.2 ±100%	2.4	.080	.88 ±100%	.29	.041	.00080
July	11	25 ± 5%	1.4 ± 77%	9.1	.030	.46 ±100%	.15	.0085	.00020
August	10	5.0 ±23%	1.3 ±100%	1.9	.060	1.1 ±100%	.37	.029	.00060
September	12	4.2 ±27%	1.2 ±100%	1.7	.060	.71 ±100%	.24	.023	.00050
October	6	6.4 ±17%	1.2 ±100%	2.1	.070	1.0 ± 60%	.33	(d)	
November	11	71 ± 2%	1.2 ±100%	8.7	.29	.94 ±100%	.31	.032	.00060
December	12	68 ± 2%	1.2 ±100%	10	.33	2.0 ± 50%	.67	(d)	
Annual average	----------	----------	----------	4.2	.12	0.86	0.29	0.17	0.0030

[a] AEC standard (HTO) = 3 000 nCi/liter.
[b] AEC standard (strontium-90) = 300 pCi/liter.
[c] AEC standard (plutonium-239 soluble) = 5 000 pCi/liter.
[d] No analyses for these months.

Table 11. Gross beta activities in Livermore water samples, January-December 1972

Sampling location	Concentration (pCi/liter)								Annual average	Percent AEC standard *
	Number of samples	January-June 1972			Number of samples	July-December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
11	6	5.4 ±27%	1.7 ± 65%	3.0	6	4.2 ±34%	2.5 ± 53%	3.3	3.1	10
12	6	3.2 ±39%	1.8 ± 68%	2.7	0					
13	6	3.8 ±38%	1.4 ±100%	2.3	3	2.7 ±47%	1.7 ±100%	2.2	2.2	7
15	6	4.9 ±28%	1.5 ±100%	3.1	5	5.4 ±29%	1.7 ± 69%	3.0	3.1	10
16	6	5.7 ±25%	3.5 ± 36%	4.7	6	6.3 ±25%	1.8 ± 68%	4.1	4.4	15
17	6	3.5 ±50%	1.7 ± 73%	2.6	6	2.9 ±46%	1.6 ±100%	2.3	2.5	8
18	6	5.7 ±26%	1.5 ±100%	3.4	0					
19	6	3.2 ±56%	1.5 ±100%	2.1	6	2.4 ±53%	1.5 ±100%	2.0	2.1	7
20	3	13 ±16%	7.3 ± 23%	9.8	3	6.7 ±25%	1.5 ±100%	4.8	7.3	24
21	6	5.4 ±64%	2.0 ± 64%	3.1	4	4.1 ±34%	1.6 ± 71%	3.2	3.2	11
22	6	12 ±16%	3.6 ± 39%	8.2	0					
23	6	6.0 ±25%	2.1 ± 60%	3.2	2	6.5 ±25%	3.3 ± 40%	4.9	4.1	14
24	6	5.0 ±38%	1.5 ±100%	3.1	2	8.2 ±22%	6.5 ± 25%	7.4	5.3	18

* AEC standard (beta activity), 30 pCi/liter.

tions 11, 15–18, and 21–24 represent surface sources such as ponds, creeks, reservoirs, and aqueducts. Livermore rainfall is sampled at location 20. The remainder of the locations represent domestic water sources. Gross beta activities are comparable to those observed during 1971. The highest activity was exhibited by the rainfall sample which is most likely due to its exposure to the relatively higher concentrations of the various natural and artificially produced radionuclides present in the atmosphere.

A number of these samples were analyzed for tritium activity. Because of the low activities, it was necessary to vacuum distill and electrolytically enrich the samples prior to liquid scintillation counting. The results of the analyses are shown in table 12. Inspection of the data indicates that the samples exhibit rather uniform tritium concentrations that are well below the AEC standards. The table also includes an estimate of the dose that may be delivered to an adult consuming water containing the listed tritium concentrations. The doses, which are typically less than 0.1 mrem, are based upon a daily water consumption of 1 liter per day (*4*) and the model of Anspaugh, *et al.* (*5*).

Table 12. Tritium activities in Livermore water samples, January-December 1972

Sampling location	Concentration (nCi/liter)								Annual average	Percent AEC standard *	Calculated annual adult whole body dose (μrem)
	Number of samples	January-June 1972			Number of samples	July-December 1972					
		Maximum	Minimum	Average		Maximum	Minimum	Average			
11	4	0.22 ± 6%	0.15 ± 5%	0.19	3	0.20 ± 7%	0.16 ± 10%	.019	0.19	0.0063	7.6
15	4	.22 ± 5%	.17 ±10%	.20	3	.20 ± 7%	.078 ± 18%	.16	.18	.0060	7.2
16	5	.35 ± 4%	.21 ± 6%	.29	3	.22 ± 7%	.11 ± 15%	.18	.23	.0076	9.2
17	4	.16 ±10%	.10 ±13%	.12	3	.15 ±11%	.11 ± 15%	.12	.12	.0040	4.7
18	4	.22 ± 7%	.17 ±10%	.19	0				.19	.0063	7.6
19	3	.19 ±10%	.062 ±13%	.12	3	.13 ±10%	.0070 ±100%	.080	.10	.0033	4.0
20	2	.39 ± 5%	.16 ± 8%	.28	2	.35 ± 5%	.34 ± 6%	.34	.31	.010	12
21	3	.27 ± 5%	.20 ± 5%	.23	2	.17 ±10%	.15 ± 8%	.16	.20	.0067	8.0
22	4	.34 ± 5%	.29 ± 7%	.30	0				.30	.010	12
23	3	1.9 ± 6%	.19 ± 5%	.80	2	.26 ± 8%	.21 ± 8%	.24	.52	.017	21
24	4	1.3 ±10%	.29 ± 4%	1.0	2	1.0 ± 2%	.60 ± 4%	.80	.90	.030	36

* AEC standard for tritium, 3 000 nCi/liter.

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Table 13. Tritium activities in Livermore vegetation samples, January-December 1972

Sampling location	Tritium activity (nCi/liter)								Annual average	Calculated whole body dose (μrem)
	Number of samples	January-June 1972			Number of samples	July-December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
4	6	0.83 ±24%	1.3 ± 58%	0.62	5	1.0 ±20%	0.19 ± 80%	0.67	0.65	8.4
5	6	6.1 ± 5%	2.1 ± 14%	3.3	5	15 ± 1%	1.3 ± 15%	2.2	2.7	40
7	6	.66 ±30%	.13 ±100%	.39	2	.31 ±66%	.17 ± 80%	.24	.31	4.7
10	6	2.8 ± 7%	.38 ± 67%	1.4	5	4.0 ± 6%	.72 ± 20%	2.3	1.9	28
11	6	7.6 ±12%	.53 ± 41%	2.7	5	1.7 ±15%	.66 ± 20%	1.2	2.0	30
12	6	1.9 ± 9%	.73 ± 31%	1.2	5	4.5 ± 4%	.80 ± 27%	2.6	1.9	28
13	6	.70 ±33%	.070 ±100%	.37	2	.55 ±38%	.30 ± 43%	.43	.40	6.0
15	6	2.2 ±11%	.11 ± 17%	1.2	5	3.3 ± 8%	.86 ± 18%	1.7	1.5	22
16	5	.69 ±28%	.33 ± 48%	.47	5	6.2 ±35%	.15 ±100%	.38	.43	6.5
17	6	.84 ±24%	.14 ±100%	.45	2	1.6 ±14%	.33 ± 39%	.95	.70	11
18	5	.48 ±46%	.21 ± 77%	.33	1			.53	.43	6.5
19	6	.64 ±34%	.13 ±100%	.30	4	15 ±15%	.21 ± 62%	.24	.27	4.0
20	6	29 ± 2%	.67 ±33 %	11	5	10 ± 1%	1.6 ± 14%	5.6	8.3	130

Vegetation

Vegetation samples (usually native grasses) were collected at monthly intervals at the locations shown in figure 2. A portion of each sample was freeze dried and the tritium activity of the recovered water was determined by liquid scintillation counting. The balance of the samples were combined to represent a monthly composite sample. After oven drying this composite sample was analyzed for various gamma-emitting radionuclides with the Ge(Li) detector used for analyzing the airborne particulate samples.

The tritium activities shown in table 13 indicate significant variation from one location to another. As the prevailing wind is from the southwest, one may expect the effect of the laboratory's operation to be minimal at locations 4, 7, 13, 17, and 18. Tritium levels found in vegetation collected from these areas, as well as locations 10 and 11 (onsite), may be exposed to the low level tritium effluent released from the Gaseous Chemistry Building. The samples collected at location 12 represent grass that has been watered by the liquid effluent from the Livermore Sewage Treatment Plant. The whole body radiation doses shown in the table were derived from the model of Anspaugh *et al.* (*5*) assuming that the observed tritium activities were typical of those in edible vegetation grown in this area. The doses are based upon the direct daily consumption of 400 g of vegetation (*4*). This mass of vegetation, however, is assumed to be equivalent to the same mass of water containing the observed tritium concentrations under equilibrium conditions. It is evident that even those samples with elevated tritium concentrations provide rather small whole body radiation doses.

The results of the gamma spectral analyses are shown in table 14. Again, if one makes the assumption that the observed activities are typical of those in edible vegetation, one may calculate the annual whole body or critical organ doses to an adult resulting from the direct ingestion of these radionuclides. These calculated doses, shown in table 14, are based upon adult consumption of 400 g per day of vegetation with a moisture content of 80 percent and the data of Ng, *et al.* (*6*), regarding the dose received per unit of radioactivity consumed under equilibrium conditions. With the exception of global fallout produced cerium-144 and natural potassium-40 activities, these radionuclides deliver appreciably less than 1 mrem/yr to the whole body or critical organ as a result of direct ingestion of edible vegetation. The cerium-144 from global fallout and the naturally occurring potassium-40 activities deliver about 10 and 25 mrem/yr to the lower large intestine and whole body, respectively.

Environmental radiation measurements

Environmental radiation background measurements were made at 12 laboratory perimeter locations shown in figure 2, and at 41 offsite

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Table 14. Activities of various radionuclides in Livermore vegetation samples, January-December 1972

Radionuclide	Concentration (pCi/g)						Annual average	Calculated annual dose via direct ingestion (mrem)	Critical organ
	January–June 1972[a]			July–December 1972[a]					
	Maximum	Minimum	Average	Maximum	Minimum	Average			
Cerium-144	7.7 ±26%	0.33 ± 88%	1.8	0.79 ±43%	0.20 ±100%	0.38	1.1	8.6	Lower large intestine
Cesium-137	.31 ±46%	.10 ±100%	.28	.68 ±50%	.10 ±100%	.22	.25	.44	Whole body
Zirconium-95	.29 ±33%	.010 ±100%	.083	.21 ±18%	.010 ±100%	.10	.090	.22	Lower large intestine
Beryllium-7	3.8 ±34%	1.0 ±100%	2.4	8.5 ±23%	1.1 ± 60%	7.1	4.8	.23	Lower large intestine
Potassium-40	25 ±12%	15 ± 22%	19	22 ±12%	12 ± 26%	17	18	25	Whole body

[a] Data based upon six samples collected monthly.

locations in the vicinity of the laboratory. These measurements were made with CaF_2:Dy (TLD–200) thermoluminescent dosimeters placed at a height of 1 meter above the ground. Exposure periods were usually 3 months. The observed exposure rates reflect the sum of terrestrial and cosmic radiation. Based on past experience, the terrestrial exposure rates in the Livermore Valley vary between 3 and 7 μR/h (26 to 61 mR/yr) depending upon the location; calculated from local elevation and geomagnetic latitudes according to the data of Lowder and Beck (*7*), is approximately 4 μR/h (35 mR/yr). Table 15 shows the quarterly exposure rates obtained at the perimeter locations. Inspection of the data reveals above average exposure rates at location 5, 13, 14, and 15. Location 5 is adjacent to a Cyclotron Building and locations 13, 14, and 15 are near a linear accelerator facility.

Site 300

Atmospheric radioactivity

The concentrations of various particulate airborne radioactive substances were measured continuously at 11 air sampling locations as shown in figures 4 and 5. Ten of the samplers are located within the boundaries of Site 300, and the 11th is located in Tracy, the primary population center of concern. The onsite sam-

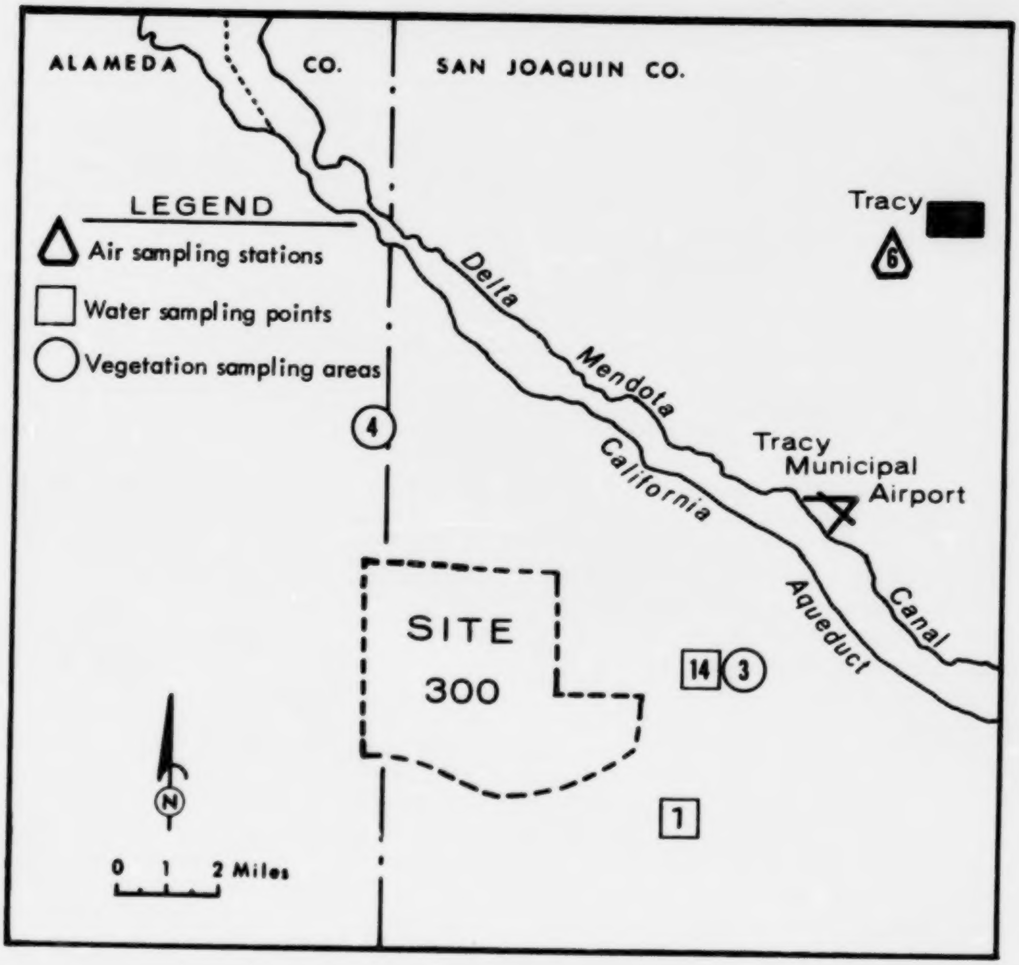
Table 15. Environmental radiation background exposure rate measurements at the Livermore Laboratory perimeter, January-December 1972

Location	January-March		April-June		July-September		October-December		Annual (mR/year)
	μR/h	mR/quarter	μR/h	mR/quarter	μR/h	mR/quarter	μR/h	mR/quarter	
1	7.8	17	9.2	20	11	24	12	26	87
2	NS	—	9.7	21	9.0	20	8.8	19	[a] 80
3	11	24	11	24	8.9	19	13	28	95
4	11	24	9.4	20	NS	—	9.5	21	[a] 87
5	12	26	15	33	13	28	16	35	[b] 122
6	9.8	21	11	24	10	22	11	24	91
7	9.2	20	7.9	17	7.9	17	9.2	20	74
8	NS	—	7.5	16	8.8	19	8.3	18	[a] 71
9	7.5	16	8.9	20	8.4	18	7.0	15	69
13	10	22	10	22	9.5	21	13	28	93
14	11	24	11	24	NS	—	12	26	[a] 99
15	12	26	12	26	9.5	21	14	31	104
Average	10	22	10	22	9.6	21	11	24	89

[a] Projected data from 3 quarters.

[b] Neutron dose measurements (using an integration rem meter) near location 5 indicate an annual dose of approximately 250 mrem additional. Neutron doses at the other perimeter locations are normally less than 10 mrem/year.

NS, no sample.


ALAMEDA CO.
SAN JOAQUIN CO.
LEGEND
Air sampling stations
Water sampling points
Vegetation sampling areas
Tracy
6
Delta Mendota Canal
California Aqueduct
Tracy Municipal Airport
4
SITE 300
14
3
1
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0 1 2 Miles

Figure 4. Air, water, and vegetation sampling locations in the Site 300 area (See figure 5 for sampling locations inside Site 300 boundary)

ples were collected on 20- by 25-cm Whatman-41 filters at a flow rate of about 0.7 m^3/min. Samples in Tracy were collected on 10- by 23-cm HV–70 (cellulose-asbestos) filters at a flow rate of about 0.1 m^3/min. Filters were changed twice weekly during the summer months to avoid excessive mass loading and on a weekly basis during the rest of the year. The filters were analyzed by the method previously described for filters used in the Livermore Valley.

No gross alpha radioactivity above the 1 pCi/m^3 detection limit was observed on these filters. The gross beta activities, averaged over 6-month periods, are listed in table 16 for each sampling location. These average radioactivities are slightly higher than those measured in the Livermore Valley, but are within the range of normal variations observed during past years. Gamma spectral measurements made on monthly composite samples of the

Table 16. Airborne particulate beta radioactivity at Site 300, January-December 1972

Sampling location [a]	Activity concentration (pCi/m³)								Annual average	Percent of AEC standard [b]
	Number of samples	January–June 1972			Number of samples	July–December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	30	0.51±1%	0.013 ± 10%	0.14	35	0.25±3%	0.0023±100%	0.068	0.10	10
2	30	.54±1%	.012 ± 11%	.14	33	.20±4%	.0034±100%	.060	.10	10
3	30	.37±2%	.016 ± 7%	.093	35	.20±4%	.013 ± 11%	.055	.074	7
4	30	.64±1%	.014 ± 9%	.12	35	.14±4%	.013 ± 16%	.053	.087	9
5	30	.47±1%	.0075± 9%	.15	35	.20±2%	.013 ± 16%	.056	.10	10
6	21	.14±2%	.0030±100%	.10	19	.45±4%	.011 ± 6%	.037	.069	7
7	29	.50±1%	.016 ± 9%	.15	31	.18±4%	.013 ± 16%	.060	.11	11
8	30	1.1 ±2%	.045 ± 5%	.34	32	.52±3%	.020 ± 21%	.051	.20	20
9	28	.76±1%	.018 ± 8%	.18	35	.20±4%	.0080± 17%	.065	.12	12
10	30	.46±1%	.015 ± 10%	.14	26	.19±7%	.011 ± 16%	.051	.096	10
11	29	.37±1%	.026 ± 4%	.14	33	.23±3%	.010 ± 20%	.055	.098	10

[a] See figures 8 and 9 for sampling locations.
[b] AEC standard is 1 pCi/m³.

filters collected onsite reveal measurable quantities of various gamma-emitting radionuclides as may be seen in table 17. These activity levels are essentially identical with those measured in the Livermore Valley and may readily be accounted for as being due to global fallout. The results of isotopic plutonium and uranium analyses, performed by the techniques described previously, are provided in table 18. The relative abundance of plutonium-238 to plutonium-239 is approximately that expected in global fallout. The uranium content of airborne debris, on the other hand, is appreciably depleted in uranium-235 relative to that of natural uranium and the concentrations are at times significantly greater than those measured in the Livermore Valley. However, these concentrations are nevertheless far lower than the current concentration guide levels.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 17 and 18 are shown in table 19. These were derived in a manner similar to that used to obtain the values in table 4. Again, these inhalation doses are extremely small with the greatest contribution being due to the cerium-144 from global fallout.

Soil

During 1971, soil samples were collected at 12 sampling locations in the vicinity of the site boundary. Isotopic uranium analyses ob-

Table 17. Results of gamma-ray spectral measurements of Site 300 perimeter air filters, January-December 1972

Month (1972)	Concentration (fCi/m³)							
	Cerium-144	Cerium-141	Antimony-125	Beryllium-7	Ruthenium-103	Ruthenium-106	Cesium-137	Zirconium-95
January	24 ± 6%	47 ± 2%	2.2 ±34%	120±6%	36 ± 4%	1.2 ± 40%	1.9 ±20%	23 ± 8%
February	18 ± 4%	6.9 ± 8%	1.2 ±32%	120±6%	.68±10%	.48± 46%	2.0 ±14%	2.6 ±10%
March	1.3± 4%	.50± 44%	.94±22%	74±4%	.27±76%	.44± 26%	1.6 ±10%	1.0 ±10%
April	27 ±58%	28 ± 2%	2.1 ±20%	170±4%	11 ± 6%	.77± 28%	3.2 ± 8%	32 ± 4%
May	38 ± 2%	38 ± 2%	2.1 ±24%	170±4%	23 ± 4%	1.1 ± 8%	3.9 ± 8%	58 ± 4%
June	39 ± 4%	36 ± 2%	2.2 ±24%	150±4%	33 ± 4%	1.4 ± 22%	4.2 ± 8%	52 ± 4%
July	21 ± 4%	18 ± 2%	1.4 ±29%	120±4%	23 ± 3%	1.0 ± 44%	2.5 ±10%	18 ± 6%
August	18 ± 5%	8.4 ± 7%	1.2 ±40%	170±5%	13 ± 7%	.85± 30%	2.6 ±12%	9.1 ± 5%
September	14 ± 6%	3.7 ± 10%	1.1 ±70%	220±4%	6.2 ±10%	.30± 42%	2.4 ±14%	5.0 ± 7%
October	6.9± 7%	.98± 22%	.56±56%	190±3%	2.1 ±13%	.39± 40%	1.2 ±16%	1.8 ± 9%
November	4.0±10%	.53± 52%	.35±67%	190±4%	1.2 ±25%	.22± 56%	.68±20%	.96±15%
December	2.9±19%	.30±100%	.46±67%	130±4%	.28±57%	.15±100%	.90±22%	.38±25%
Annual average	18	16	1.3	150	13	0.69	2.3	17
AEC standard [a]	200 000	5×10⁶	900 000	4×10⁷	3×10⁶	200 000	500 000	1×10⁶
Percent of AEC standard	0.0090	0.00032	0.00015	0.00038	0.00043	0.00035	0.00045	0.0017

[a] Assumes the activity is in an insoluble form.

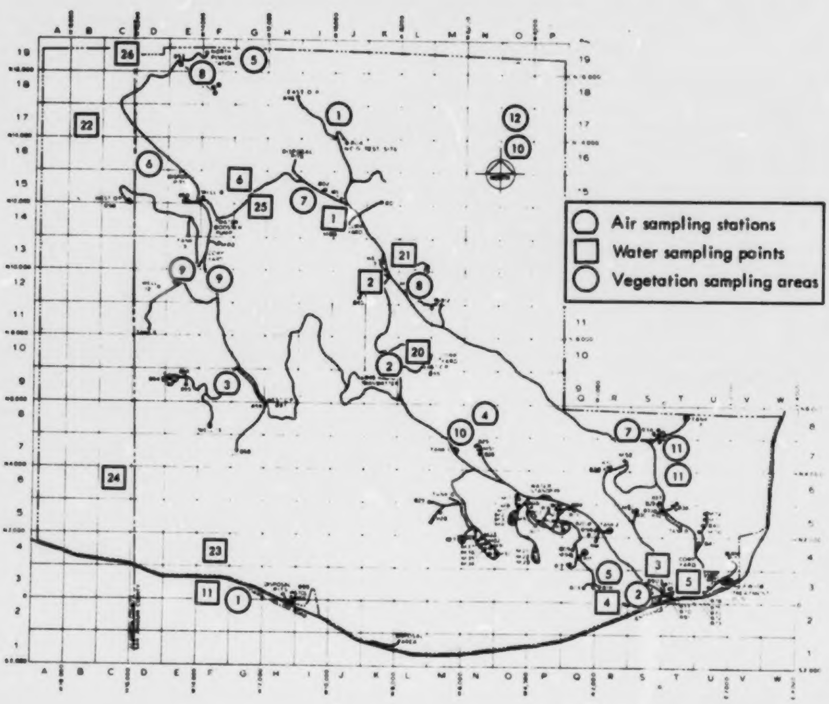
○ Air sampling stations
□ Water sampling points
○ Vegetation sampling areas
A B C D E F G H I J K L M N O P Q R S T U V W

Figure 5. Air, water, and vegetation sampling locations inside Site 300 boundary

Table 18. Plutonium and uranium concentrations in Site 300 air, January-December 1972

Month (1972)	Activity (aCi/m^3)		^{238}Pu/^{239}Pu	Mass (pg/m^3)		(^{235}U/^{238}U)[a]
	Plutonium-238	Plutonium-239		Uranium-235[c]	Uranium-238	
January	1.9 ±12%	20 ± 6%	0.095	1.3 ±1%	800 ±6%	0.0017
February	2.3 ± 9%	25 ± 5%	.092	4.6 ±1%	2 300 ±5%	.0020
March	1.9 ± 8%	20 ± 5%	.095	.39 ±2%	130 ±4%	.0030
April	4.8 ± 9%	45 ± 6%	.11	.78 ±2%	170 ±3%	.0046
May	5.7 ±10%	62 ± 6%	.092	.68 ±2%	170 ±4%	.0040
June	5.7 ± 8%	71 ± 6%	.080	.80 ±1%	180 ±3%	.0043
July	2.7 ±28%	48 ±11%	.056	51 ±1%	100 ±2%	.0051
August	1.5 ±12%	17 ± 6%	.088	(b)	(b)	(b)
September	1.1 ±12%	15 ± 5%	.073	(b)	(b)	(b)
October	.59 ±21%	8.4 ± 8%	.070	.43 ±1%	140 ±2%	.0031
November	1.1 ±11%	12 ± 6%	.092	.81 ±1%	360 ±2%	.0023
December	1.6 ±19%	13 ± 9%	.12	.56 ±1%	260 ±2%	.0022
Annual average	2.4	29		1.1	460	
AEC standard	1×10^6	1×10^6		1.9×10^4	1.5×10^7	
Percent of AEC standard	0.00024	0.0029		0.0058	0.0031	

[a] The ^{235}U/^{238}U ratio in natural uranium is 0.00725.
[b] No data.
[c] Assumes the activity is in an insoluble form.

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Table 19. Inhalation doses resulting from the air concentrations shown in tables 17 and 18

Radionuclide	Calculated annual lung dose (mrem)
Cerium-144	0.30
Cerium-141	.036
Antimony-125	.044
Beryllium-7	.031
Ruthenium-103	.043
Ruthenium-106	.013
Cesium-137	.012
Zirconium-95	.11
Plutonium-238	.0018
Plutonium-239	.020
Uranium-235	.014
Uranium-238	.084

tained by mass spectrometric techniques indicated that the ^{235}U/^{238}U ratios in the soil were slightly depleted in uranium-235 which might have resulted from the expenditure of depleted uranium in the high explosive detonations being conducted at the site. Therefore, a major soil sampling program was undertaken during 1972 to determine the extent to which the normal ^{235}U/^{238}U ratio in soil samples was perturbed throughout the test site as a result of laboratory operations.

Soil samples were collected at the locations shown in figure 6, using the sampling techniques previously described for collecting soil samples in the Livermore Valley. The results of the isotopic uranium analyses are shown in table 20.

By using the ^{235}U/^{238}U ratio in the depleted uranium expended in the high explosive detonations and that in natural uranium, one may calculate the relative amounts of natural and

Table 20. Concentrations of uranium in Site 300 soils, January-December 1972

Sampling location	Depth (cm)	Uranium-234 (pg/g dry weight)	Uranium-235 (ng/g dry weight)	Uranium-236 (pg/g dry weight)	Uranium-238 (µg/g dry weight)	^{235}U/^{238}U	Total uranium (µg/g dry weight)	Total natural uranium (µg/g dry weight)	Total depleted uranium (µg/g dry weight)
13	0- 5	884 ± 3%	239 ±1%	4 020 ± 2%	124 ± 5%	0.00196	124 ±5%	3.63	120
	5-10	566 ± 4%	152 ±1%	2 530 ± 1%	75.8 ± 5%	.00203	76.0 ±5%	3.18	72.8
	10-15	286 ± 4%	70.0 ±1%	1 060 ± 3%	32.2 ± 5%	.00220	32.3 ±5%	2.36	30.0
	15-20	198 ±16%	40.6 ±2%	510 ±10%	16.7 ± 5%	.00247	16.7 ±5%	2.05	14.6
	20-25	177 ± 6%	37.0 ±2%	409 ± 4%	14.5 ± 3%	.00259	14.5 ±4%	2.10	12.4
14	0- 5	317 ±35%	72.8 ±1%	971 ± 2%	31.1 ± 5%	.00237	31.1 ±5%	3.28	27.9
	5-10	180 ± 4%	32.0 ±2%	206 ± 3%	9.33 ± 4%	.00347	9.36 ±4%	2.87	6.49
	10-15	168 ± 6%	26.4 ±2%	106 ± 7%	5.93 ± 4%	.00451	5.96 ±4%	2.97	2.99
	15-20	143 ± 4%	21.8 ±1%	50.9 ± 6%	4.26 ± 3%	.00517	4.28 ±3%	2.66	1.63
	20-25	123 ± 4%	19.2 ±2%	51.3 ± 6%	3.77 ± 3%	.00516	3.79 ±3%	2.34	1.45
15	0- 5	151 ± 2%	25.5 ±1%	151 ± 2%	6.88 ± 2%	.00375	6.90 ±2%	2.47	4.43
	5-25	120 ± 2%	17.8 ±1%	41.8 ± 3%	3.33 ± 2%	.00540	3.35 ±2%	2.22	1.13
16	0- 5	107 ± 4%	15.9 ±1%	24.4 ± 7%	2.64 ± 2%	.00610	2.65 ±2%	2.10	.56
	5-25	107 ± 2%	15.8 ±1%	27.6 ± 4%	2.76 ± 2%	.00580	2.77 ±2%	2.04	.74
17	0- 5	306 ± 3%	82.6 ±1%	1 680 ± 1%	43.2 ± 2%	.00194	43.3 ±2%	1.06	42.2
	5-10	191 ± 5%	47.6 ±1%	660 ± 3%	20.5 ± 3%	.00235	20.6 ±3%	2.06	18.5
	10-15	101 ± 2%	17.4 ±1%	83.2 ± 2%	4.18 ± 2%	.00420	4.20 ±2%	1.85	2.34
	15-20	109 ± 6%	17.7 ±1%	69.5 ± 6%	3.81 ± 2%	.00471	3.83 ±2%	2.05	1.78
	20-25	103 ± 4%	15.9 ±1%	42.6 ± 6%	3.03 ± 2%	.00533	3.04 ±2%	1.98	1.07
18	0- 5	170 ± 5%	31.6 ±1%	295 ± 3%	10.8 ± 1%	.00298	10.8 ±1%	2.30	8.50
	5-25	128 ± 3%	18.5 ±1%	18 ±11%	2.94 ± 2%	.00638	2.96 ±2%	2.50	.47
19	0- 5	322 ± 2%	76.7 ±1%	1 040 ± 1%	36.2 ± 1%	.00214	36.3 ±1%	2.30	34.0
	5-25	149 ± 2%	33.3 ±1%	397 ± 1%	14.1 ± 2%	.00239	14.2 ±2%	1.50	12.6
20	0- 5	89 ± 8%	11.7 ±2%	7.5 ±24%	1.70 ± 3%	.00694	1.71 ±3%	1.62	.10
	5-25	98 ±10%	12.5 ±2%	7.2 ±36%	1.77 ± 3%	.00714	1.75 ±3%	1.74	.04
21	0- 5	108 ± 7%	13.9 ±1%	8.9 ±22%	2.06 ± 3%	.00683	2.07 ±3%	1.91	.16
	5-25	99 ± 7%	12.7 ±2%	6.1 ±22%	1.78 ± 5%	.00721	1.80 ±4%	1.78	.02
22	0- 5	88 ± 7%	11.8 ±2%	7.4 ±22%	1.74 ± 3%	.00686	1.78 ±3%	1.62	.12
	5-25	94 ± 6%	12.4 ±2%	3.6 ±33%	1.73 ± 3%	.00726	1.74 ±3%	1.74	.0
23	0- 5	1 380 ± 3%	335 ±1%	4 110 ± 2%	147 ± 5%	.00230	148 ±5%	13.5	134
	5-25	86 ± 5%	13.1 ±2%	13 ±15%	2.07 ± 3%	.00644	2.08 ±3%	1.77	.31
24	0- 5	97 ± 4%	14.9 ±1%	25 ± 8%	2.51 ± 3%	.00602	2.52 ±3%	1.96	.57
	5-25	95 ± 4%	14.4 ±1%	5.0 ±20%	2.05 ± 3%	.00708	2.07 ±3%	2.00	.06
25	0- 5	82 ± 4%	1.37 ±8%	51 ± 4%	2.95 ± 2%	.00470	2.97 ±2%	1.58	1.39
	5-10	62 ± 5%	9.82 ±1%	17 ± 6%	1.69 ± 2%	.00588	1.70 ±2%	1.27	.43
	10-15	75 ± 3%	11.6 ±1%	16 ± 6%	1.93 ± 2%	.00608	1.94 ±2%	1.52	.42
	15-20	56 ± 5%	9.08 ±1%	14 ± 7%	1.53 ± 1%	.00600	1.54 ±1%	1.19	.35
26	0- 5	117 ± 3%	22.4 ±2%	194 ± 3%	7.53 ± 4%	.00302	7.55 ±4%	1.69	5.86
	5-25	79 ± 5%	12.1 ±2%	13 ±15%	1.93 ± 3%	.00637	1.94 ±3%	1.61	.31
27	0- 2	93 ± 4%	13.9 ±1%	12 ±15%	2.20 ± 3%	.00639	2.22 ±3%	1.87	.35
	2-25	96 ± 4%	14.5 ±1%	7.0 ±14%	2.09 ± 3%	.00703	2.10 ±3%	2.02	.08
28	0- 2	77 ± 5%	11.0 ±2%	10 ±20%	1.70 ± 4%	.00651	1.71 ±4%	1.48	.23
	2-25	83 ± 5%	11.7 ±2%	5.0 ±20%	1.68 ± 2%	.00704	1.69 ±2%	1.62	.07
29	0- 2	89 ± 5%	12.4 ±2%	11 ±18%	1.90 ± 3%	.00659	1.91 ±3%	1.68	.23
	2-25	95 ± 4%	12.9 ±2%	5.0 ±20%	1.82 ± 3%	.00719	1.83 ±3%	1.81	.02
30	0-25	103 ± 3%	17.1 ±1%	86 ± 2%	4.47 ± 2%	.00387	4.48 ±2%	1.70	2.78
31	0-25	101 ± 3%	18.2 ±1%	103 ± 3%	5.21 ± 2%	.00354	5.23 ±2%	1.67	3.56
32	0-25	120 ± 3%	17.4 ±1%	11 ± 9%	2.60 ± 2%	.00678	2.62 ±2%	2.39	.22
33	0-25	87 ± 2%	13.4 ±1%	10 ±10%	2.01 ± 1%	.00678	2.02 ±2%	1.84	.17
34	0-25	94 ± 3%	13.8 ±1%	11 ± 9%	2.02 ± 1%	.00689	2.04 ±2%	1.90	.13
35	0-25	102 ± 3%	17.0 ±1%	85 ± 1%	4.32 ± 2%	.00398	4.34 ±2%	1.74	2.60
36	0-25	133 ± 2%	20.0 ±1%	21 ± 5%	3.09 ± 2%	.00654	3.11 ±2%	2.71	.41
37	0-25	90 ± 3%	12.8 ±1%	15 ± 7%	2.11 ± 2%	.00617	2.12 ±2%	1.70	.42

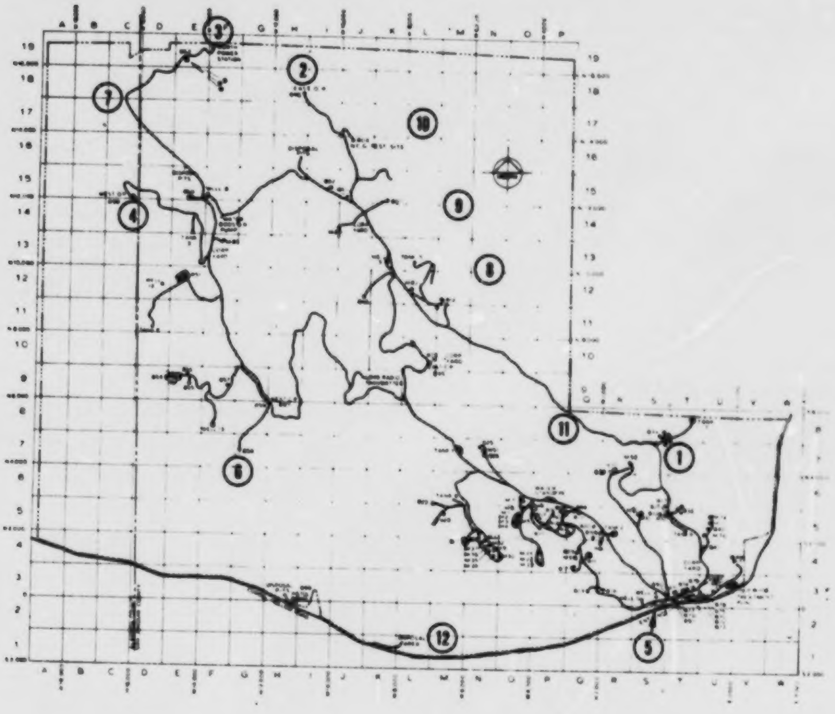

Figure 6. Site 300 soil sampling locations

depleted uranium in the samples. These data are also included in table 20. Inspection of the data indicates that detectable amounts of depleted uranium may be found in samples collected as much as 500 m from the firing bunkers. Depth profile studies at locations 13, 14, and 17 show that the depleted uranium may be found to the maximum depth sampled probably as a result of natural erosion and/or mechanical mixing processes. Samples collected more than roughly 500 m away from the firing bunkers show essentially no detectable amounts of depleted uranium. While it is clear that the laboratory's operations have produced a detectable increase in uranium near the firing bunkers, the affected areas are well within the site boundaries.

Some of the samples were also subjected to plutonium analysis by standard radiochemical techniques. The results of the analyses are shown in table 21. A review of the data indicates the activity levels are similar to those measured within the Livermore Valley and

Table 21. Plutonium activities in Site 300 soils, January-December 1972

Sampling location	Activity			Deposition
	Depth (cm)	Plutonium-238 (aCi/g)	Plutonium-239 (fCi/g)	Plutonium-239 (nCi/m²)
13	0–25		2.3± 9%	0.87
14	0–25		2.8± 9%	1.0
15	0–25	64 ±38%	2.1± 8%	.75
16	0–25	41 ±45%	1.3± 9%	.51
17	0–25	100 ±44%	2.8±10%	1.0
18	0–25	140 ±28%	3.5± 7%	1.4
19	0–25	140 ±32%	1.7±10%	.75
20	0–25	9.0±41%	2.1±12%	.74
21	0–25	55 ±41%	2.6±10%	1.0
22	0–25	55 ±39%	1.9±12%	.73
23	0–25	20 ±24%	5.5± 6%	2.2
24	0–25	150 ±22%	3.0± 6%	1.1
25	0– 5	320 ±25%	6.0± 8%	
	5–10	110 ±28%	3.0± 7%	
	10–15	90 ±40%	1.9±10%	
	15–20	45 ±44%	1.3± 9%	
	20–25	190 ±23%	1.7±10%	
	0–25	150 ±32%	3.0± 8%	1.1
26	0–25	120 ±29%	2.6± 7%	.96
27	0–25	160 ±24%	2.1± 8%	.76
28	0–25	310 ±20%	3.1± 8%	1.2
29	0–25	250 ±22%	1.6±10%	.60
30	0–25	220 ±27%	3.4± 8%	1.3
31	0–25	140 ±31%	2.1±10%	.82
32	0–25	80 ±40%	2.5± 9%	.93
33	0–25	120 ±34%	2.0±10%	.74
34	0–25	110 ±38%	2.5± 9%	.94
35	0–25	100 ±29%	2.4± 9%	.88
36	0–25	180 ±30%	2.2±10%	.83
37	0–25	110 ±36%	2.0±10%	.74

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may readily be accounted for as being due to global fallout.

Water

Samples were collected from onsite wells supplying Site 300 and from various onsite and offsite springs, ponds, and creeks. The locations of these sites are shown in figures 4 and 5. Locations 1 through 7 represent deep-well sources, locations 11 and 14 are offsite creek sources, and rain water is collected at location 20. The remaining locations are onsite ponds or springs. The samples were subjected to gross alpha and beta analyses. No samples showed a gross alpha activity above the limit of detection of 1.2 pCi/liter. The gross beta activities averaged over 6-month periods are given in table 22. These activities show little variation with time and location and are similar to those exhibited by the water samples collected within the Livermore Valley.

These samples were also subjected to tritium analyses by electrolytic enrichment and subsequent scintillation counting. The results of the analyses are shown in table 23. With the exception of samples collected at location 25, these samples contain tritium activities that are comparable with those observed in water samples collected within the Livermore Valley. Water in the spring at location 25 does not appear to migrate, as a nearby deep-water well

Table 22. Gross beta activities in Site 300 water samples, January-December 1972

Sample location	Number of samples	Concentration (pCi/liter)							Annual average	Percent AEC standard[a]
		January-June 1972			Number of samples	July-December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	5	2.8 ±56%	1.8 ± 53%	2.2	5	12 ±17%	2.0 ± 60%	5.0	3.6	12
2	5	5.8 ±26%	3.7 ± 42%	4.3	5	11 ±17%	4.4 ± 32%	5.8	5.1	17
3	5	7.6 ±21%	2.2 ± 57%	5.6	5	13 ±16%	3.6 ± 41%	6.5	6.1	20
4	2	5.4 ±29%	2.9 ± 42%	4.1	2	3.4 ±37%	2.6 ± 54%	3.0	3.6	12
5	5	6.0 ±25%	3.4 ± 38%	5.0	5	12 ±16%	4.0 ± 38%	5.9	5.5	18
6	5	5.5 ±31%	2.1 ± 53%	4.2	5	11 ±18%	3.4 ± 38%	5.3	4.8	16
7	5	6.1 ±30%	4.3 ± 31%	5.3	5	11 ±17%	4.6 ± 34%	6.4	5.9	20
11	4	9.8 ±18%	4.2 ± 38%	6.3	5	14 ±15%	7.2 ± 23%	9.4	7.9	26
14	3	5.5 ±27%	2.8 ± 43%	4.1	1			5.6	4.9	16
20	1			3.8	2	11 ±17%	1.7 ±100%	6.5	5.2	17
21	4	16 ±30%	2.6 ± 60%	7.1	4	15 ±14%	7.3 ± 23%	10	8.6	29
23	4	7.3 ±22%	6.4 ± 27%	7.0	4	13 ±15%	5.8 ± 26%	8.2	7.6	25
24	4	8.0 ±21%	5.5 ± 28%	6.3	4	13 ±16%	6.7 ± 23%	8.4	7.4	25
25	5	3.6 ±38%	1.6 ±100%	2.5	4	9.4 ±19%	3.9 ± 34%	5.2	3.9	13
26	4	6.0 ±29%	2.3 ± 67%	4.7	4	11 ±18%	5.8 ± 26%	7.0	5.9	20

[a] AEC standard (beta activity) = 30 pCi/liter.

Table 23. Tritium activities in Site 300 water samples, January-December 1972

Sample location	Number of samples	Concentration (pCi/liter)							Annual average	Percent AEC standard[a]	Calculated annual adult whole body dose (μrem)
		January-June 1972			Number of samples	July-December 1972					
		Maximum	Minimum	Average		Maximum	Minimum	Average			
1	2	17 ± 88%	11 ±100%	14	4	320 ±43%	8.0 ±100%	90	52	.0017	2.1
2	2	17 ± 94%	11 ±100%	14	3	45 ±27%	8.0 ±100%	32	23	.00077	.92
3	3	14 ± 95%	4.9 ±100%	8.0	3	59 ±27%	12 ±100%	30	19	.00063	.76
5	3	31 ± 40%	24 ± 57%	26	3	43 ±28%	22 ± 60%	31	28	.00093	1.1
6	2	14 ± 80%	3.0 ±100%	8.5	3	29 ±41%	9.0 ±100%	17	13	.00043	.52
7	3	11 ±100%	11 ±100%	11	3	20 ±60%	17 ±100%	19	15	.00050	.60
11	3	430 ± 4%	5.0 ±100%	170	2	16 ±75%	9.0 ±100%	12	90	.0030	3.6
20	2	95 ± 15%	94 ± 14%	95	0				95	.0032	3.8
21	2	30 ± 69%	19 ± 37%	25	3	190 ± 9%	36 ± 42%	93	59	.0020	2.4
23	3	200 ± 8%	14 ±100%	77	3	20 ±55%	8.0 ±100%	15	46	.0015	1.8
24	2	23 ± 57%	5.0 ±100%	14	3	20 ±55%	11 ±100%	16	15	.00050	.60
25	4	810 000 ± 2%	670 000 ± 2%	770 000	4	1 000 000 ± 2%	710 000 ± 2%	830 000	800 000	27	32 000
26	2	28 ± 50%	11 ±100%	19	3	16 ±69%	10 ±100%	12	16	.00053	.64

[a] AEC standard (HTO) = 3 μCi/liter.

at location 6 exhibits normal background tritium levels.

Table 23 also includes the calculated whole body doses to an adult consuming the water containing the listed tritium concentrations. These doses were derived in a manner similar to that used to compute the values listed in table 9. As one would expect, the doses are insignificant with the exception of the spring at location 25. However, the water from this spring percolates back into the ground a few feet from the spring, and is not used in laboratory operations or for drinking.

Vegetation

Vegetation samples were collected on a monthly basis with the exception of May and December at 12 sampling locations shown in figure 5. Dried monthly composite samples were subjected to gamma spectral analyses yielding the activities of cesium-137, cerium-144, beryllium-7, and potassium-40. The results of the analyses are shown in table 24. Also shown in the table are the calculated whole body or critical organ doses delivered to an adult by direct ingestation of 400 grams per day of edible vegetation containing 80 percent water and the listed average activities. Again, the data reveal that potassium-40 and cerium-144 are the major contributors via this pathway.

These samples were also subjected to tritium analyses by freeze-drying and scintillation counting of the resulting water. The results are shown in table 25. The activities show little fluctuation compared with the results obtained from similar samples collected within the Livermore Valley. The table also includes the resulting whole body doses delivered to an adult by the tritium activities based upon the models referenced previously. As one would expect these doses are insignificant.

Table 24. Activities of various radionuclides in Site 300 vegetation samples, January-December 1972

Radionuc ide	Concentration (pCi/g)						Annual average	Calculated annual dose via direct ingestion (mrem)	Critical organ
	January-June 1972[a]			July-December 1972[a]					
	Maximum	Minimum	Average	Maximum	Minimum	Average			
Cerium-144	2.0 ±20%	0.35 ±100%	0.84	0.92 ±41%	0.34 ±100%	0.56	0.70	5.5	Lower large intestine
Cesium-137	.18 ±74%	.080 ±100%	.13	.15 ±82%	.043 ±100%	.14	.14	.25	Whole body
Beryllium-7	3.8 ±34%	1.9 ± 48%	2.6	6.7 ±34%	1.5 ± 50%	3.3	3.0	.15	Lower large intestine
Potassium-40	31 ±20%	16 ± 30%	22	26 ±29%	13 ± 28%	19	21	29	Whole body

[a] Based on 5 samples.

Table 25. Tritium activities in Site 300 vegetation samples, January-December 1972

Sample location	Concentration (pCi/liter)									Calculated annual adult whole body dose (μrem)
	Number of samples	January-June 1972			Number of samples	July-December 1972			Annual average	
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	3	160 ±100%	18 ±100%	100	4	260 ±80%	18 ±100%	180	140	2
2	4	10 000 ± 3%	18 ±100%	3 600	4	150 ±90%	18 ±100%	130	1 800	30
3	5	410 ± 40%	18 ±100%	240	4	280 ±54%	18 ±100%	250	240	4
4	3	550 ± 50%	18 ±100%	390	4	390 ±39%	18 ±100%	250	320	5
5	4	450 ± 35%	18 ±100%	290	3	420 ±36%	220 ± 74%	330	310	5
6	4	8 100 ± 3%	18 ±100%	4 500	2	92 000 ± 1%	2 100 ± 8%	47 000	26 000	400
7	5	680 ± 23%	18 ±100%	230	4	360 ±42%	18 ±100%	300	260	4
8	3	770 ± 21%	18 ±100%	320	4	1 100 ±15%	18 ±100%	410	370	6
9	5	600 ± 37%	18 ±100%	400	4	2 300 ± 9%	640 ± 34%	920	660	10
10	5	550 ± 48%	18 ±100%	200	4	270 ±62%	18 ±100%	160	180	3
11	5	400 ± 65%	18 ±100%	190	3	420 ±50%	18 ±100%	220	200	3
12	4	310 ± 53%	18 ±100%	250	3	460 ±45%	18 ±100%	280	260	4

Table 26. Radionuclide activity observed in milk samples, January-December 1972

Radionuclide	Number of samples	Concentration (pCi/liter)			Calculated annual adult radiation dose (mrem)	Critical organ
		Maximum	Minimum	Average		
Cesium-137	6	5.2	1.8	2.7	0.016	Whole body
Cerium-144	7	87	13	33	.84	Lower large intestine
Tritium	8	290	110	170	.00052	Wnole body
Potassium-40	3	1 400	1 300	1 400	6.3	Whole body

Milk

The only dairy in the general vicinity of laboratory operations is located about 10 km southwest of Tracy. Periodic milk samples were collected from the dairy throughout the year. Before analysis, the samples were concentrated by means of freeze drying, which normally yields about 2 liters of concentrate from 9 liters of fresh milk. The concentrates were subjected to gamma spectral analysis by counting them between two 20 by 10 cm NaI(Tl) crystals. In addition, each sample was analyzed for tritium activity by counting 1 ml of the water recovered from freeze drying in a liquid scintillation counting system. Activities of cesium-137, cerium-144, potassium-40, and tritium are shown in table 26. Also shown are the calculated annual adult whole body or critical organ radiation dose delivered to man via the milk pathway. These calculations are based on a daily intake of 260 g/day (*4*) and the models previously referenced. As expected, the only significant dose to an individual is that from naturally occurring potasium-40.

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Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	October 1973

2. National Reactor Testing Station[3] January-December 1972

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) was established in 1949 by the U.S. Atomic Energy Commission (AEC) to promote reactor development by building, testing, and operating various types of nuclear reactors, allied plants, and equipment. By 1972, 50 reactors had been built at the NRTS and 16 were still operating or operable.

The NRTS is situated on the Upper Snake River Plain in southeastern Idaho at an average elevation of 1500 meters. The station is comprised of 16 200 km^2 of sagebrush and basalt fields and the boundary stretches 63 km northwest of Blackfoot, 80 km northwest of Pocatello, and 11 km southeast of Arco, Idaho (figure 7).

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[3] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, "National Reactor Testing Station, 1972."

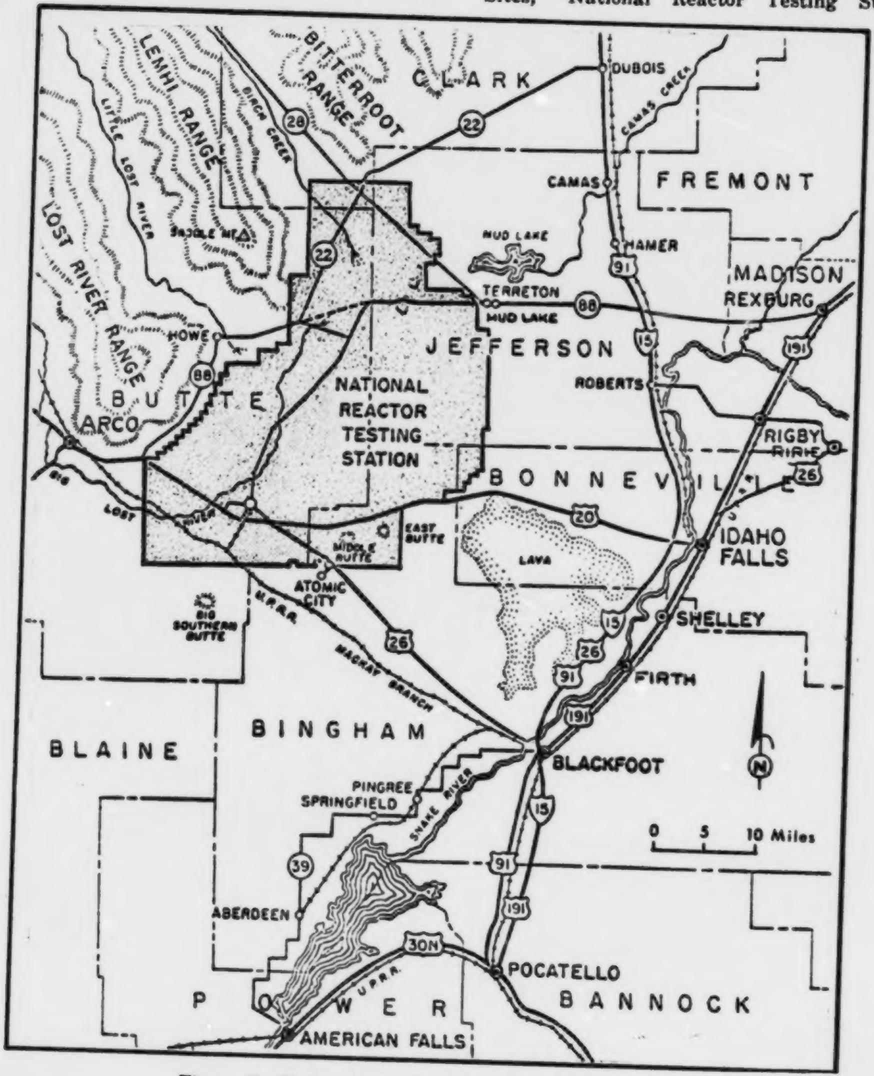
LEMHI RANGE
BITTERROOT RANGE
CLARK
DUBOIS
CAMAS CREEK
BIRCH CREEK
LITTLE LOST RIVER
LOST RIVER RANGE
SADDLE MT.
28
22
CAMAS
FREMONT
MUD LAKE
HAMER
91
MADISON
REXBURG
TERRETON
MUD LAKE
88
HOWE
JEFFERSON
15
191
ROBERTS
BUTTE
ARCO
NATIONAL REACTOR TESTING STATION
RIGBY
RIRIE
26
BONNEVILLE
BIG LOST RIVER
20
EAST BUTTE
MIDDLE BUTTE
LAVA
IDAHO FALLS
ATOMIC CITY
BIG SOUTHERN BUTTE
U.P.R.R.
MACKAY BRANCH
SHELLEY
FIRTH
BINGHAM
BLAINE
BLACKFOOT
N
PINGREE
SPRINGFIELD
SNAKE RIVER
0 5 10 Miles
39
ABERDEEN
30N
POCATELLO
POWER
BANNOCK
AMERICAN FALLS

Figure 7. National Reactor Testing Station environs

127

Although annual precipitation in the NRTS area has averaged only 22 cm, underlying the desert plain is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about 4 billion liters per day. Aquifer water is supplied principally from Henry's Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. The underground water seeps slowly at a rate of 1.5 to 6 meters per day to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho. Both aquifer and surface waters of the Snake River are used for irrigation of crops.

Major programs currently underway at the NRTS fall into five major categories. One program provides test irradiation services from the two operating high-flux test reactors, the ETR and ATR. The Idaho Chemical Processing Plant (ICPP) recovers uranium from highly enriched spent fuels. A third major program is that of light-water-cooled reactor safety testing and research. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are the major projects in the reactor safety program. Other significant programs include the operation of the Experimental Breeder Reactor II (EBR–II) by Argonne National Laboratory and the operation of the Naval Reactor Facility (NRF).

Because of these small activities, small amounts of radioactivity were released to the atmosphere and the Snake River Plain aquifer. In its environmental monitoring program, the Health Services Laboratory (HSL) of the AEC measured the levels of radioactivity in air, groundwater, surface water, milk, and wheat samples. Gamma radiation exposures in air were also measured.

Air monitoring

Air samplers were operated continuously and drew air through sets of filters for weekly periods. A membrane prefilter (Gelman Model AN–800) for collection of particulates was followed by an inline activated charcoal-impregnated cellulose fiber filter (Gelman Model AS–1) for removal of radioiodine from the air stream. An average air flow of approximately 0.03 cubic meters per minute was maintained. Air samplers were located onsite, in the small communities close to the NRTS boundary, and at distant background sites (figure 8). The locations provide comprehensive surveillance of atmospheric radioactivity and theoretically made it possible to differentiate worldwide fallout from NRTS releases. The air sampling network was expanded during 1972 by adding samplers at two additional boundary communities (Monteview, Reno Ranch) and one onsite (EFS) location.

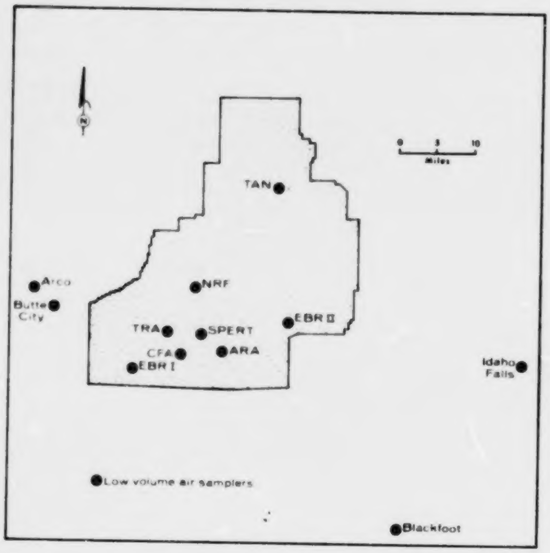

Figure 8. Onsite and offsite air sampling locations National Reactor Testing Station

The filters were analyzed 5 days after the end of each sampling period to allow for decay of short-lived natural radioactivity. Gross alpha and beta analyses were performed on the membrane filters, and gross beta analyses alone were performed on the charcoal filters. Activity detected on the charcoal filters was assumed to be iodine-131. Gross alpha activity was determined by a technique reported by Hallden and Harley (7). Using this method, an alpha-sensitive phosphor disc was placed in direct contact with the filter and counted with a low-noise photomultiplier tube. For gross beta analyses, the filters were mounted on a ringed phanchet and counted in a low background beta counter. At the end of each calender quarter, the particulate filters from selected locations were composited and the concentrations of gamma-emitting radionuclides determined by gamma spectrometry. A strontium-90 analysis was also performed on the quarterly composites. Each membrane filter was dried and weighed before and after use to determine the average airborne particulate concentration during the sampling period.

Onsite air samples were collected at locations close to the sources of released radioactivity and were expected to have the highest concentrations. Background samples were collected at Idaho Falls, Blackfoot, and Pocatello. These locations were sufficiently remote to ensure that any radioactivity detected was due to natural background or sources other than NRTS operations. Levels of radioactivity in onsite and boundary community (Arco, Monteview, Reno Ranch, Butte City, Howe, and Mud Lake) air samples were compared to levels in the background samples. If the radioactivity levels were found to be significantly higher than background, the net amount above background was assumed to be radioactivity introduced to the environment from NRTS operations. The net concentrations of radioactivity were then compared to the AEC standards set forth in the U.S. Atomic Energy Commission's Manual Chapter 0524 (AECM). The air sampling data are presented in table 27.

Table 27. Radioactivity in air, National Reactor Testing Station, January-December 1972

Sampling locations	Number of samples	Type of analysis and filter	Minimum detectable concentration (fCi/m³)	Maximum single concentration (fCi/m³)	Average sample concentration (fCi/m³)	Average background concentration (fCi/m³)	Maximum average net concentration (fCi/m³)	AEC standard (fCi/m³)
Onsite (9 locations)	428	Gross α —membrane	1	4.0	1.6	(a)	1.6	6 000
		Gross β —membrane	10	4 600	290	280	10	[b] 30 000
		Gross β —charcoal	10	59	<20	<20	<20	9×10⁶
EBR-1 (onsite)	52	^{90}Sr —membrane	(d)	[c] 9.3	5.7	2.0	3.7	1×10⁶
		^{95}Zr —membrane	(d)	[c] 26	<11	<12	<11	3×10⁷
		^{95}Nb —membrane	(d)	[c] 45	<16	<17	<16	1×10⁸
		^{103}Ru —membrane	(d)	[c] 13	<5.4	6.5	<5.4	8×10⁷
		^{106}Ru-Rh —membrane	(d)	[c] 25	(e)	----------	----------	6×10⁶
		^{125}Sb —membrane	(d)	[c] 5.2	(e)	----------	----------	3×10⁷
		^{137}Cs —membrane	(d)	[c] 11	<7.1	<3.5	<7.1	1×10⁷
		^{141}Ce —membrane	(d)	[c] 18	<6.9	<5.7	<6.9	2×10⁸
		^{144}Ce-Pr —membrane	(d)	[c] 43	<22	<16	<22	6×10⁶
Arco (Boundary community)	52	Gross α —membrane	1	3.8	1.7	(a)	1.7	20
		Gross β —membrane	10	1 500	300	280	20	[b] 1 000
		Gross β —charcoal	10	750	<30	<20	<30	1×10⁵
Howe (Boundary community)	52	Gross α —membrane	1	3.6	1.6	(a)	1.6	20
		Gross β —membrane	10	1 500	260	280	None	[b] 1 000
		Gross β —charcoal	10	420	<20	<20	<20	1×10⁵
Monteview (Boundary community)	52	Gross α —membrane	1	4.3	1.6	(a)	1.6	20
		Gross β —membrane	10	3 100	250	280	None	[b] 1 000
		Gross β —charcoal	10	250	<20	<20	< 20	1×10⁵
Reno Ranch (Boundary community)	52	Gross α —membrane	1	3.2	1.5	(a)	1.5	20
		Gross β —membrane	10	1 700	250	280	None	[b] 1 000
		Gross β —charcoal	10	140	<10	<20	<10	1×10⁵
Butte City (Boundary community)	52	Gross α —membrane	1	2.9	1.5	(a)	1.5	20
		Gross β —membrane	10	2 000	260	280	None	[b] 1 000
		Gross β —charcoal	10	600	<30	<20	<30	1×10⁵
		^{90}Sr —membrane	(d)	[c] 3.8	2.7	2.0	.7	30 000
		^{95}Zr —membrane	(d)	[c] 22	<9.3	<12	<9.3	1×10⁶
		^{95}Nb —membrane	(d)	[c] 25	<12	<17	<12	3×10⁶
		^{103}Ru —membrane	(d)	[c] 12	(e)	----------	----------	3×10⁶
		^{125}Sb —membrane	(d)	[c] 11	(e)	----------	----------	9×10⁵
		^{137}Cs —membrane	(d)	[c] 14	<5.7	<3.5	<.57	5×10⁵
		^{141}Ce —membrane	(d)	[c] 14	(e)	----------	----------	5×10⁶
		^{144}Ce-Pr —membrane	(d)	[c] 39	(e)	----------	----------	2×10⁵
Mudd Lake (Boundary community)	52	Gross α —membrane	1	4.4	1.8	(a)	1.8	20
		Gross β —membrane	10	1 500	250	280	None	[b] 1 000
		Gross β —charcoal	10	160	<10	<20	<10	1×10⁵
		^{90}Sr —membrane	(d)	[c] 3.7	1.9	2.0	None	30 000
		^{95}Zr —membrane	(d)	[c] 26	<10	<12	<10	1×10⁶
		^{95}Nb —membrane	(d)	[c] 33	<12	<17	<12	3×10⁶
		^{103}Ru —membrane	(d)	[c] 14	5.6	<6.5	<5.6	3×10⁶
		^{106}Ru-Rh —membrane	(d)	[c] 24	(e)	----------	----------	2×10⁵
		^{137}Cs —membrane	(d)	[c] 5.0	(e)	----------	----------	5×10⁵
		^{141}Ce —membrane	(d)	[c] 14	(e)	----------	----------	5×10⁶
		^{144}Ce-Pr —membrane	(d)	[c] 39	<20	<16	<20	2×10⁵

[a] Background gross alpha concentrations representative of the NRTS were not available.
[b] Assumes actinium-227 not present.
[c] The maximum quarterly average.
[d] Detection limits varied because of different air flow volumes and counting times for these quarterly composite samples.
[e] A meaningful average could not be computed; the radionuclide was detected in only one of two quarterly composite samples.

The gross alpha air concentrations at the background locations of Idaho Falls, Blackfoot, and Pocatello were not representative of the NRTS background levels. This was due to higher airborne concentrations of naturally occurring radioactivity in the upper Snake River Valley. Therefore, the onsite and NRTS boundary community gross alpha concentrations are not compared to an average background concentration. In determining the maximum net average concentration of gross alpha activity presented in table 27, the background was assumed to be zero. However, if measurable onsite releases of alpha activity were occurring, it would have been expected that the gross alpha concentrations at onsite locations would be higher than at the communities near the NRTS boundary. This pattern was not observed and indicates the gross alpha concentrations measured at the NRTS and boundary community locations were the result of natural background radioactivity.

During 1972, two foreign atmospheric tests of nuclear devices took place. One test occurred January 7, 1972, and the other on March 18, 1972. Increased levels of airborne radioactivity were observed at all sampling locations following these tests. Because of the local nature of some of the natural aerosol clearing processes (such as scattered showers), the amount of increase in radioactivity at each location varied. During these periods, the establishment of a known background air concentration was impossible and valid comparisons between onsite, boundary community, and background air concentrations of radioactivity could not be made.

Except when fresh worldwide fallout was present, all the gross beta (iodine-131) concentrations determined from the charcoal filters were near or below the detection limit of the analysis. The highest gross beta (iodine-131) concentration found on a charcoal filter was 0.75 pCi/m^3 and this occurred at Arco, Idaho following the January 7, 1972 foreign atmospheric test. Even this maximum concentration was well below the standard of 100 pCi/m^3.

For 1972, the average gross beta (long life only) concentration of particulate material at onsite locations was 0.29 pCi/m^3. The highest individual average was 0.36 pCi/m^3, occurring at the TRA sampling location. These concentrations are lower than the average and maximum which occurred last year (1971) of 0.65 pCi/m^3 and 0.82 pCi/m^3, respectively. All onsite concentrations in air were well below the standard of 30 pCi/m^3.

The 1972 averages would have been even lower if the foreign atmospheric tests had not been conducted. The yearly average concentration of background gross beta activity was 0.28 pCi/m^3. Although the overall onsite average of gross beta activity in air was only slightly above the background level, a few onsite locations did have concentrations as much as 26 percent above background. The small differences between the onsite and background concentrations were likely the result of releases of small quantities of radioactivity from onsite facilities. Fission and activation products identified on the onsite particulate filters were cerium-praseodymium-144, cerium-141, cesium-137, antimony-125, ruthenium-rhodium-106, ruthenium-103, niobium-95, and strontium-90. Except for antimony-125 and ruthenium-rhodium-106, the same radionuclides were identified on the background filters in approximately the same amounts. This is further evidence that most of the long life gross beta activity is the result of worldwide fallout and not NRTS operations.

At the six boundary community air sampling locations, the average gross beta concentration of 0.26 pCi/m^3 was not statistically different from the background concentration of 0.28 pCi/m^3. These levels too would have been lower if not for the fallout from foreign nuclear device testing in the atmosphere. Only the radionuclides identified on the background filters were also identified on the boundary community filter. Thus, there is no evidence which suggests an increase in the concentrations of radioactivity in air at the boundary community locations.

The monthly average onsite and background location gross beta air concentrations (long life only) for 1970, 1971, and 1972 are plotted in figure 9. The monthly average boundary community gross beta concentrations are also plotted for 1971 and 1972. These air concen-

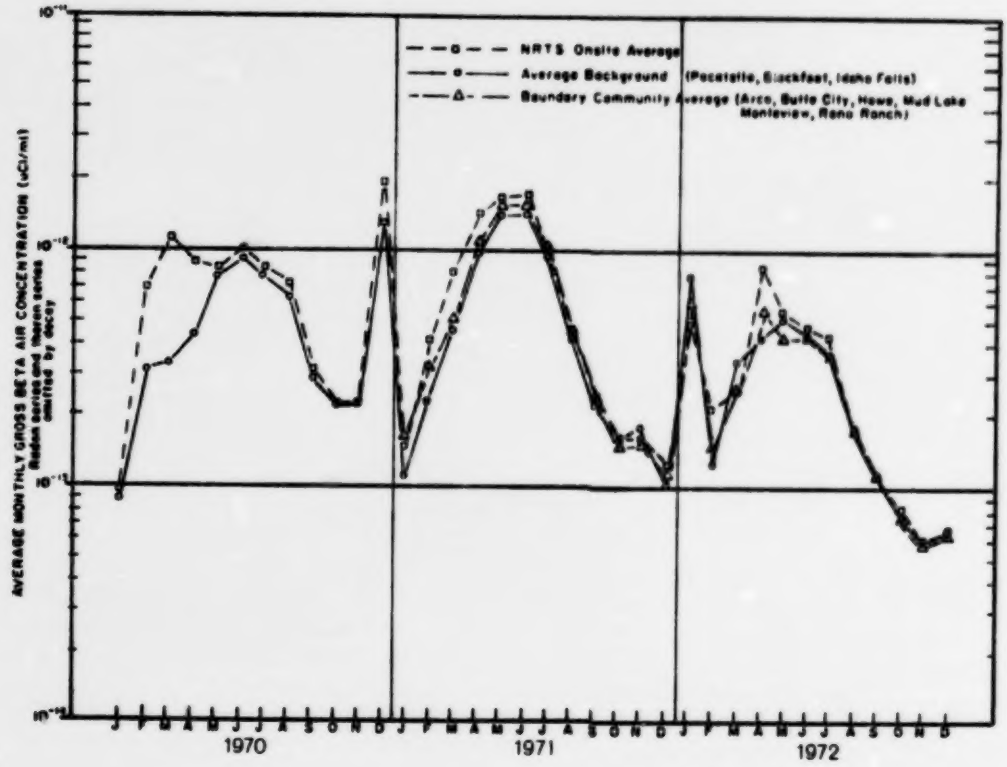

Figure 9. Variation in worldwide fallout plus NRTS released gross beta concentrations with time of year

trations are mainly due to worldwide fallout activity from nuclear tests. Increases in the onsite average above world fallout levels such as occurred early in 1970, the first half of 1971, and the middle of 1972 are likely the result of atmospheric releases from the NRTS. Sharp increases in both onsite and offsite concentrations as measured late in 1970 and early in 1972 were the result of fresh radioactive fallout from the testing of nuclear devices at sites other than the NRTS. The scatter between the background average and the boundary community average during the first half of 1972 is a result of the local variation in the levels of fresh fallout from the foreign atmospheric testing. The rise in background during the spring and summer months of each year is due to the increased transport of stratospheric air and its accompanying radioactivity during those seasons.

Water monitoring

Water samples were collected from onsite and offsite drinking water production wells and from the Snake River. Onsite and offsite water sampling locations can be seen in figures 10 and 11, respectively. All offsite samples were collected semiannually; onsite samples were generally collected every 2 weeks. Gross alpha, gross beta, and tritium analyses were routinely performed on the water samples. For gross alpha analysis, an aliquot of the sample was evaporated on a stainless steel planchet and counted with a scintillation counter using a technique similar to that described for the gross alpha analysis for the air filters. Another aliquot was evaporated and counted for gross beta activity in a low background beta counter. Tritium concentrations were determined with a Beckman Scintillation System. Water sam-

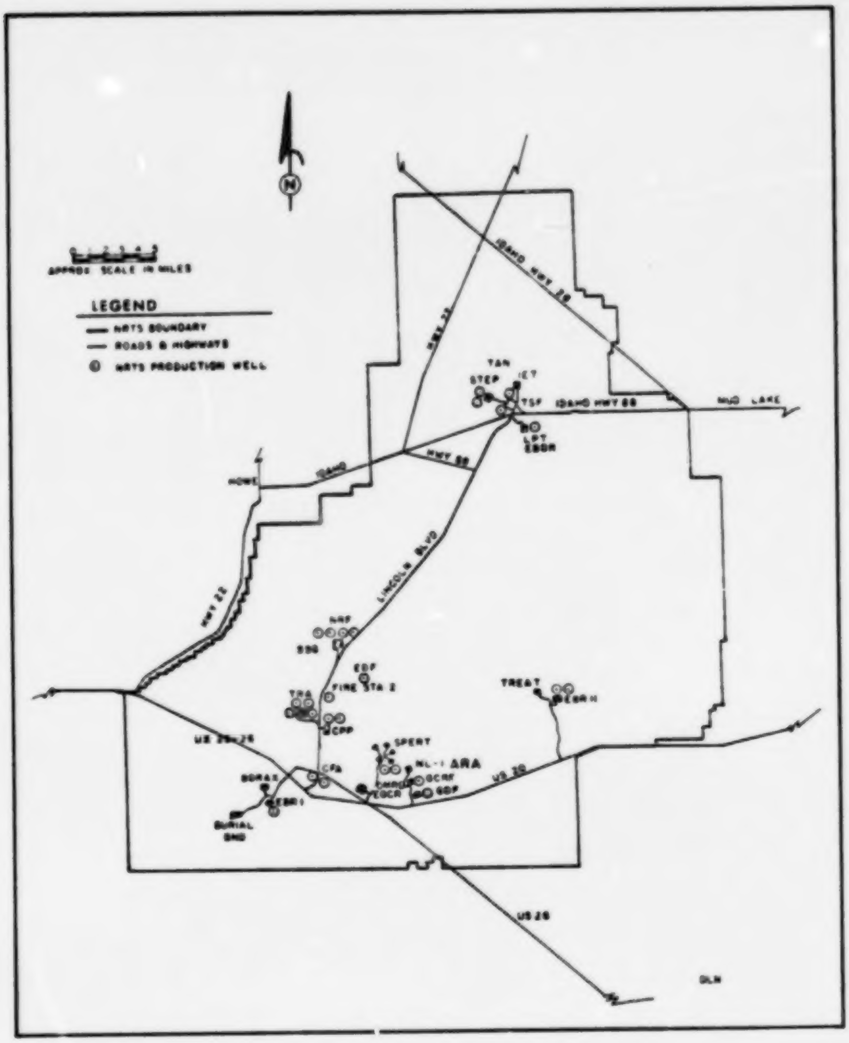
N
APPROX SCALE IN MILES
LEGEND
NRTS BOUNDARY
ROADS & HIGHWAYS
NRTS PRODUCTION WELL
IDAHO HWY 28
HWY 22
TAN
STEP
IET
TSF
IDAHO HWY 88
MUD LAKE
LPT
EBOR
HOWE
IDAHO
HWY 88
LINCOLN BLVD
HWY 22
NRF
SSG
EOF
FIRE STA 2
TREAT
EBR II
TRA
ICPP
US 20-26
SPERT
ML-1
ARA
CFA
BORAX
EBR I
BURIAL GND
EOCR
GCRE
SDF
US 20
US 26

Figure 10. Onsite water sampling locations, NRTS

pling data are presented in tables 28 and 29. Samples collected from Mud Lake, Monteview, Reno Ranch, Idaho Falls, and Roberts (all upgradient in the aquifer from the NRTS) were used to determine background concentrations of radioactivity.

None of the offsite water samples collected during 1972 contained concentrations of radioactivity above the detection limits of the analyses. No onsite samples contained gross alpha concentrations above the detection limit of 3 pCi/liter. Of the wells used for drinking purposes, the highest single sample gross beta concentration, 33 pCi/liter, was found in well #1 at the Idaho Chemical Processing Plant. The 1972 average strontium-90 concentration

Table 28. Radioactivity in well water samples, National Reactor Testing Station, January-December 1972

Sampling locations	Number of samples	Type of analysis	Minimum detectable concentration (pCi/liter)	Maximum single samples concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration (pCi/liter)	Maximum average net concentration (pCi/liter)
EBR-I (1 well)	1	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	(b)	(b)	(b)	(b)
CFA (2 wells)	26	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]99	[c]70	(b)	[c]70
TRA (3 wells)	104	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)
ICPP (2 wells)	26	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	33	<12	(b)	<12
		Tritium	[c]2	[c]19	[c]6.0	(b)	[c]6.0
		Strontium-90	1	17	5.7	NA	5.7
NRF (3 wells)	42	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	(b)	(b)	(b)	(b)
TAN (5 wells	129	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)
SPERT-PBF (2 wells)	26	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)
ARA (2 wells)	52	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)
EBR-II (1 well)	26	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)
Fire station #2 (1 well)	26	Gross α	3	(b)	(b)	(b)	(b)
		Gross β	5	(b)	(b)	(b)	(b)
		Tritium	[c]2	[c]2	(b)	(b)	(b)

[a] AEC standards—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium 3 000 nCi/liter, and strontium-90, 300 pCi/liter.
[b] Below detection limit.
[c] Concentration of tritium in nCi/liter.

Table 29. Radioactivity in offsite drinking water and surface water samples, National Reactor Testing Station, January-December 1972

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration (pCi/liter)	Average background concentration[a] (pCi/liter)	Maximum average net concentration (pCi/liter)
Carey, Aberdeen, Shoshone, Atomic City, Minidoka, and Arco:	12	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)
Snake River at Bliss, Idaho:	2	Gross alpha	(b)	3	(b)	(b)	(b)
		Gross beta	(b)	5	(b)	(b)	(b)
		Tritium	(b)	[c]2	(b)	(b)	(b)

[a] AEC standard—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter.
[b] Below detection limit.
[c] Concentration of tritium in nCi/liter.

at the ICPP was 5.7 pCi/liter. This strontium-90 concentration is less than 2 percent of the AECM standard. The highest 1972 average tritium concentration, 7 nCi/liter, was found at the Central Facilities Area (CFA) and was 2.3 percent of the AECM 0524 standard.

Food monitoring

Milk was the main foodstuff sampled. A composite grade A sample was collected from farm areas to the north and south of Idaho Falls each week. Monthly grade B milk samples were collected from dairies and individual farms in rural areas surrounding the NRTS. Analysis by gamma spectrometry for iodine-131 and cesium-137 was performed on all milk samples. Semiannually the samples were analyzed for strontium-90. Wheat samples were collected from individual farms and grain elevators during the fall harvest and analyzed for gamma-emitting radionuclides by gamma spectrometry and for strontium-90. Milk and wheat sampling locations are shown in figure 10.

All milk sampling results summarized in table 30 were compared to standards recommended by the Federal Radiation Council, since the AECM 0524 does not list concentration guides for milk. During 1972, the concentrations of iodine-131 and cesium-137 in milk were below the detection limits of the analysis. Strontium-90 concentrations in milk were less than 3 percent of the standard and were attributed to worldwide fallout, not NRTS operations. Only strontium-90 activity was detected in the wheat samples with the hull containing 90 percent of the total. This means only 10 percent of the activity will remain after the wheat is processed for use in food products. The strontium-90 in wheat is also attributed to worldwide fallout. Wheat sampling results are located in table 31.

Gamma radiation exposure

Environmental gamma radiation exposures were measured with thermoluminescent dosimeters (TLD) placed at background and NRTS boundary community locations. Exposures at

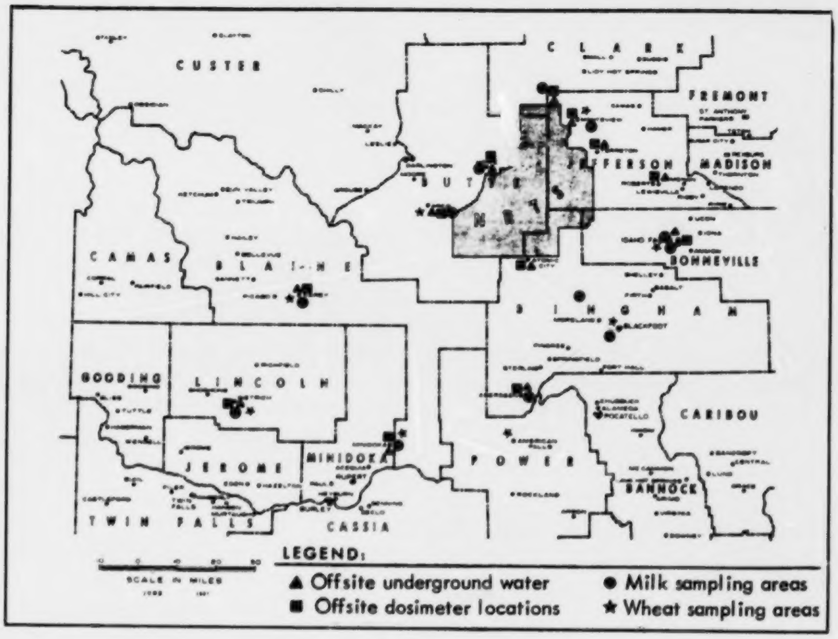
CUSTER
CLARK
FREMONT
JEFFERSON
MADISON
BUTTE
NRTS
BONNEVILLE
CAMAS
BLAINE
BINGHAM
GOODING
LINCOLN
CARIBOU
JEROME
MINIDOKA
POWER
BANNOCK
TWIN FALLS
CASSIA
SCALE IN MILES
LEGEND:
▲ Offsite underground water
■ Offsite dosimeter locations
● Milk sampling areas
★ Wheat sampling areas

Figure 11. Environmental monitoring program, National Reactor Testing Station

Table 30. Radionuclide concentration in milk, National Reactor Testing Station, January-December 1972

Location and sampling frequency	Analysis	Concentration (pCi/liter)		
		Maximum single sample concentration	Minimum detectable concentration	Average sample concentration[a]
Idaho Falls: (weekly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	6.5	2	4.7
Minidoka: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	6.0	2	4.5
Dietrich: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	11	2	<6.5
Carey: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	5.4	2	<3.7
Mud Lake: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	6.3	2	6.1
Reno Ranch: (monthly)	Iodine-131	(b)	20	(b)
	Cesiun-137	(b)	30	(b)
	Strontium-90[c]	4.6	2	3.8
Tabor: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	4.3	2	4.3
Howe: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	<3.3	(d)	<2.6
Arco: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	4.6	2	<3.3
Firth and New Sweden, near Idaho Falls: (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	2.7	2	2.7
Lake and Riverside (Tabor-Blackfoot-Aberdeen Area): (monthly)	Iodine-131	(b)	20	(b)
	Cesium-137	(b)	30	(b)
	Strontium-90[c]	4.0	2	3.4

[a] Federal Radiation Council standard: Iodine-131, 100 pCi/liter; cesium-137, 3 600 pCi/liter; strontium-90, 200 pCi/liter.
[b] Below detection limit.
[c] Only two samples during the year were analyzed for strontium-90.
[d] The detection limit for one sample was 3.3 pCi/liter and 2 pCi/liter for the other.

Table 31. Strontium-90 concentrations in wheat, NRTS, January-December 1972

Sampling location	Strontium-90 concentration (pCi/g)
Minidoka	0.021
Dietrich	.022
Carey	.016
Arco	.011
Monteview	.025
Idaho Falls	.022
Blackfoot	.010
American Falls	.013

the distant locations of Idaho Falls, Blackfoot, Dietrich, Carey, Aberdeen, and Minidoka were considered background levels. Measurements of boundary community exposures were made at Atomic City, Howe, Arco, Butte City, Mud Lake, and Roberts. The exposures reported in table 32 are for the period April 25 to November 20, 1972. The average exposure at each location and its associated error at the 95 percent confidence level (2σ) are listed. Boundary community exposures ranged from 81 ± 11 to 111 ± 36 mR. Background exposures ranged from 80 ± 6 to 101 ± 11 mR. There was no evidence that any of the exposures at the NRTS boundary communities were different from background or were the result of NRTS activities.

Table 32. Offsite gamma exposure, NRTS, April 25-November 20, 1972

Location	Exposure (mR $\pm 2\sigma$)	Equivalent yearly exposure (mR $\pm 2\sigma$)
Boundary community exposures:		
Howe	81 ±11	141 ±19
Monteview	83 ±12	145 ±21
Reno Ranch	82 ±10	143 ±17
Atomic City	111 ±36	194 ±63
Arco	84 ±13	147 ±23
Butte City	85 ±16	148 ±28
Mud Lake	87 ±12	152 ±21
Background exposures:		
Minidoka	80 ± 6	140 ±10
Aberdeen	100 ±12	175 ±21
Roberts	101 ±11	176 ±19
Blackfoot	86 ± 6	150 ±10

Summary

The results of the air monitoring program for 1972 indicated that onsite and offsite air concentrations resulting from NRTS releases were indistinguishable from the natural radioactivity in air. However, special techniques were used to measure worldwide radioactive fallout, which is usually much less than 1 percent of the natural radioactivity in air. These sensitive techniques indicated that at a few onsite sampling locations the small releases of NRTS radioactivity were measurable above the worldwide fallout. There was no evidence that NRTS operations caused any increased air concentrations at offsite communities.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits of the analyses. The only fission or activation product detected in milk samples was strontium-90. However, the strontium-90 concentrations are similar to those reported for the region in the U.S. Environmental Protection Agency's *Radiation Data and Reports*, and the source is assumed to be fallout from nuclear device testing and not NRTS operations. Wheat samples collected at harvest also contained small amounts of strontium-90 from worldwide fallout.

Gamma radiation exposures were measured simultaneously at distant background locations and at communities near the NRTS boundary. There was no evidence that the exposures at the NRTS boundary communities were different from background.

REFERENCE

(8) HALLDEN and HARLEY. An improved alpha counting technique. Anal Chem 32:1861 (1960).

Recent coverage in *Radiation Data and Reports:*

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January-December 1971	March 1974

136

Reported Nuclear Detonations, October 1974

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on October 16, 1974. The signals originated at 2:33 a.m. EDT, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

There were no reported nuclear detonations for the United States for October 1974.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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RADIATION DATA AND REPORTS

Volume 15, Number 12, December 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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NOTICE

This issue of *Radiation Data and Reports,* which marks the completion of fifteen volume years of monthly publication, is its final issue.

Future publications of the Office of Radiation Programs, Environmental Protection Agency, will take new directions in emphasis and presentation of information. These publications will present information in depth, with interpretations leading to assessments of the environmental and health significance of radiation and analyses of trends. Reports of individual investigations by scientists in the field will no longer be published.

For those who have a need for specific raw data from the ERAMS program, these can be obtained by request to the

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The Office of Radiation Programs takes this opportunity to acknowledge the past support of our readers, and the contributions of so many who cooperated with us in the past. We look forward to opportunities for continued service, with our new format, to the agencies, organizations, and individuals, and to the public, in our role of providing focus on the various radiation problems that concern our society.

W. D. Rowe

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

Reports

A Summary of Low-Level Radioactive Wastes Buried at Commercial Sites Between 1962-1973, with Projections to the Year 2000

M. F. O'Connell[1] *and W. F. Holcomb*[2]

The U.S. Environmental Protection Agency contracted with the six States having commercial burial facilities for low-level radioactive wastes to obtain inventories of the types and quantities of wastes buried at these six sites. A compilation and interpretation of the inventory data is presented in tables and figures. Projections are made to the year 2000 of the quantity of low-level radioactive wastes that will result from the nuclear fuel cycle and nonfuel cycle sources. In addition, assumptions are made relating these projections to the available capacity and operational life of the commercial sites. Based on estimates of waste generation rates, it is indicated, assuming present operational practices, that by the year 1998, the six existing sites will exhaust their current burial capacity.

The disposal of low-level radioactive wastes at commercially-operated burial sites began in 1962 at Beatty, Nev. Since that time, the industry has expanded to include three private companies operating six sites. The sites are located at Maxey Flats, Ky.; Beatty, Nev.; Sheffield, Ill.; Barnwell, S.C.; West Valley, N.Y.; and Richland, Wash. The three companies operating these facilities are Nuclear Engineering Company (Washington, Nevada, Illinois and Kentucky), Chem Nuclear Systems, Incorporated (South Carolina), and Nuclear Fuel Services (New York). Earlier reports have described these sites in some detail (*1,2,3*). These facilities are located in remote areas in geologic conditions which were considered suitable for the purpose of shallow land burial of low-level radioactive wastes.

The burial facilities are managed by private industry, but, by regulation, are located upon Federal- or State-owned land (*4*) and have controlled access. They are, in general, regulated by the State in which they are located, according to the provision of agreements between the individual States and the U.S. Atomic Energy Commission (AEC). The one exception is the site located at Sheffield, Ill., which is regulated directly by the AEC. At two sites, those located in Nevada and Washington, the AEC has retained the licensing and regulation of the handling of special nuclear material.

The licenses for the burial of radioactive waste generally contain provisions for site maintenance, inventory control, health and safety, and environmental monitoring. The AEC and agreement States have issued a total of 29 other licenses to companies for the purpose of collecting, packaging, storing, and transporting radioactive wastes from the users of radioactive materials to the commercial disposal facilities. These companies are not involved with the actual disposal of the waste, but act only as intermediaries (*5*).

The burial facilities were initially to receive the radioactive wastes from hospitals, research facilities, and industries using radioisotopes. However, over the past 11 years, these sites have also been used increasingly for the disposal of contaminated waste material and equipment from the growing commercial nuclear power industry (fuel fabrication, reactor operation, and fuel reprocessing).

In the latter part of 1971, the U.S. Environmental Protection Agency's Office of Radiation Programs (ORP) contracted with each of the six States to obtain complete inventories of the types and quantities of byproduct material, source material, special nuclear material and

---

[1] Office of Radiation Programs—Las Vegas Facility, Las Vegas, Nev.

[2] Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460.

(41)

liquid waste buried from the time the site began operation through 1973. The data submitted by the States were taken from periodic reports prepared and submitted by the companies operating the burial sites. The companies tabulate the waste burial data from shipping records prepared by the facilities shipping waste to the burial site for disposal.

Presentation of inventory data

Low-level solid radioactive wastes are those which neither originate from the first extraction process of the nuclear fuel reprocessing operation nor generate sufficient heat or radiation so as to require special cooling or shielding. These low-level wastes are categorized, depending upon the isotopes they contain, as byproduct, special nuclear material, and source material and are briefly defined below (*4*):

1. *Byproduct material* (reported in curies) refers to any radioactive material (except nuclear material and source material) obtained during the production or use of source or special nuclear material and includes fission products and other radioisotopes.

2. *Source material* (reported in pounds) refers to thorium or uranium or any combination thereof, in any physical or chemical form. Source material does not include special nuclear material.

3. *Special nuclear material* (SNM) (reported in grams) refers to plutonium, uranium-233, uranium containing more than the natural abundance of the isotope 235 or any material artificially enriched in any of these substances. SNM does not include source material.

Tables 1 through 5 present a compilation of the State inventory data. The accompanying figures 1 through 5 present these data where comparisons between sites can be made and regional or national trends can be observed.

Interpretation of figures

Figure 1 shows a continuing increase in the volume of waste being buried over the reporting period. Notably, the South Carolina facility, though only opened in 1971, has quickly become one of the nation's major burial sites. This is not unexpected since the growth of the nuclear industry in the southeastern United States has been greater than in most other regions. From current nuclear power projections and other indications of planned nuclear industry growth, it is estimated that this region will become a major contributor of low-level radioactive solid waste. Before this site opened in 1971, the major burial facility in the United States was the one located in Kentucky, receiving almost 40 percent of the volume of all low-level wastes being buried at commercial facilities. The Kentucky site will probably continue to receive large volumes of waste for burial, but it is expected that the other burial facilities will be utilized to a greater extent in the future

Table 1. Volume of radioactive wastes buried at commercial sites, 1962–1973

Year	Volume (cubic feet)							
	Kentucky	Nevada	South Carolina	Illinois	New York	Washington	National annual total	National cumulative total
1962		65 704					65 704	65 704
1963	77 905	124 035			18 425		220 365	286 069
1964	136 736	100 150			225 597		462 483	748 552
1965	203 109	70 195			166 564	23 602	463 470	1 212 022
1966	196 205	124 779			165 872	84 839	571 695	1 783 717
1967	276 158	113 228		89 240	174 657	30 705	683 988	2 467 705
1968	288 757	126 272		95 805	159 084	23 620	693 538	3 161 243
1969	365 596	151 202		71 053	150 948	15 463	754 262	3 915 505
1970	442 128	145 895		99 760	179 960	14 923	882 666	4 798 171
1971	465 145	126 558	48 253	156 455	224 687	20 615	1 041 713	5 839 884
1972	550 082	151 901	159 485	210 336	249 117	235 895	1 556 816	7 396 700
1973	355 703	143 930	603 876	301 018	[a]250 000	[a]100 000	[a]1 750 000	[a]9 150 000
Total	3 357 524	1 443 849	811 614	1 023 667	[a]1 960 000	[a]550 000	[a]1 750 000	[a]9 150 000

[a] Estimated.

Table 2. Byproduct material buried at commercial sites, 1962–1973

Year	Byproduct material (curies)							
	Kentucky	Nevada	South Carolina	Illinois	New York [a]	Washington	National annual total	National cumulative total
1962								
1963	22 556	5 690			1 372		29 618	29 618
1964	147 218	6 477			11 355		165 050	194 668
1965	63 828	6 377			21 515	144	91 864	286 532
1966	52 737	11 974			41 056	1 006	106 773	393 305
1967	23 272	10 894		3 850	51 230	5 378	94 624	487 929
1968	45 578	6 808		2 381	51 675	10 330	116 772	604 701
1969	31 028	9 761		2 192	23 264	55 964	122 209	726 910
1970	56 969	12 304		5 427	36 291	52 820	163 811	890 721
1971	710 147	4 316	224	7 895	42 458	23 916	788 956	1 679 677
1972	217 350	5 228	13 682	4 857	61 208	20 000	322 325	2 002 002
1973	123 779	5 704	107 662	2 834	[b] 40 000	[b] 25 000	[b] 300 000	[b] 2 300 000
Total	1 494 462	85 533	121 568	29 436	[b] 350 000	[b] 190 000		[b] 2 300 000

[a] Plutonium-238 subtracted from figures in column. New York reports plutonium-238 as byproduct material instead of special nuclear material, whereas the other States report plutonium-238 as special nuclear material.

[b] Estimated.

Table 3. Special nuclear material buried at commercial sites, 1962–1973

Year	Special nuclear material (grams)							
	Kentucky	Nevada	South Carolina	Illinois	New York [a]	Washington	National annual total	National cumulative total
1962		319					319	319
1963	959	41 304			952		43 215	43 534
1964	11 770	172 030			3 273		187 073	230 607
1965	4 261	334 762			2 433	3	341 459	572 066
1966	7 462	5 872			4 999	1 418	19 751	591 817
1967	14 842	22 644		1 238	3 446		42 170	633 987
1968	17 771	8 602		1 754	2 045		30 172	664 159
1969	31 506	5 005		3 843	7 301	32	47 687	711 846
1970	47 562	7 708		5 649	8 273	200	69 392	781 238
1971	72 770	757	55 877	9 934	4 816	15	144 169	925 407
1972	71 443	21 177	64 993	5 898	7 321		170 832	1 096 239
1973	46 249	15 164	77 149	6 126	[b] 4 000		[b] 150 000	[b] 1 240 000
Total	326 595	635 344	198 019	34 442	[b] 490 000	1 668		[b] 1 240 000

[a] Plutonium-238 added to figures supplied by New York State.

[b] Estimated.

Table 4. Source material buried at commercial sites, 1962–1973

Year	Source material (pounds)							
	Kentucky	Nevada	South Carolina	Illinois	New York	Washington	National annual total	National cumulative total
1962		653					653	653
1963	11 487	1 041			16 716		29 244	29 897
1964	12 333	729			22 197		35 259	65 156
1965	1 252	520			48 987	2	50 761	115 917
1966	1 521	200			84 492	558	86 771	202 688
1967	12 516	763		8 664	44 699	2	66 644	269 332
1968	13 772	2 300		19 192	14 244	6	49 514	318 846
1969	5 631	639		13 963	176 401	195	196 829	515 675
1970	15 913	711		4 420	69 931	69	90 044	606 719
1971	12 643		26 716	467	113 438	1 337	154 601	761 320
1972	18 205	20 596	35 057	7 927	159 930	[a] 4 000	[a] 246 000	[a] 1 007 000
1973	24 224	25 264	86 111	5 310	[a] 100 000	[a] 5 000	[a] 245 000	[a] 1 250 000
Total	129 497	53 416	147 884	59 943	[a] 850 000	[a] 11 000		[a] 1 250 000

[a] Estimated.

Table 5. Liquids received for disposal at commercial sites, 1962–1971[a]

Year	Quantity[b] (gallons)				
	Kentucky	Nevada	Washington	National annual total	National cumulative total
1962		128 000		128 000	128 000
1963	18 514	130 438		148 952	276 952
1964	31 624	41 145		72 769	349 721
1965	32 325	21 474	443	54 242	403 963
1966	22 047	52 030	616	74 693	478 656
1967	30 590	12 429	5 204	48 223	526 879
1968	55 497	32 325	2 813	90 635	617 514
1969	44 762	23 151	737	68 650	686 164
1970	20 009	7 790	666	28 465	714 629
1971	339 009	34 452	115	373 576	1 088 205
Total	594 377	483 234	10 594		1 088 205

[a] No liquids accepted at commercial sites for 1972–1973.
[b] Liquids never accepted in South Carolina, Illinois, or New York.

because of the economic considerations associated with transportation costs.

In figure 2, the unusually large increase in the total radioactivity buried at Kentucky in 1971, was due to a single package of tritium-contaminated waste (645 000 curies) from a Federal research facility. To relate the radioactivity buried to the volume of waste is difficult since the activity concentration in the waste depends upon the originating source and the use of radioactive material at the source. For nuclear power plants, the waste shipments have averaged 0.15 Ci/cubic foot from pres-

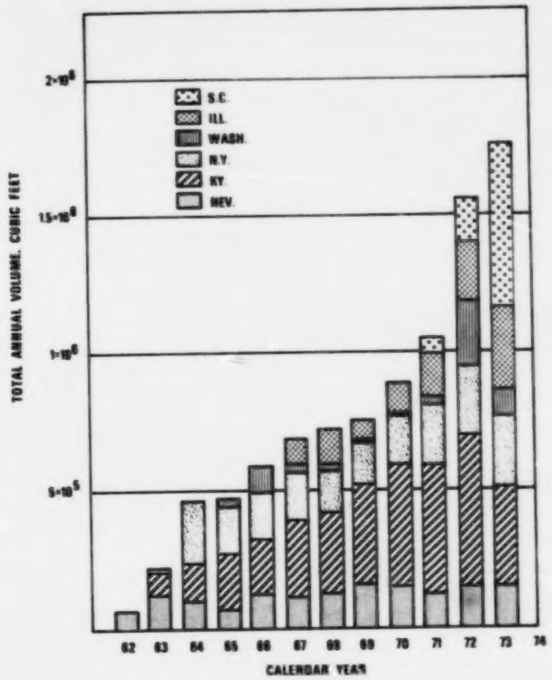

Figure 1. Total volume of radioactive wastes buried at commercial sites in the United States

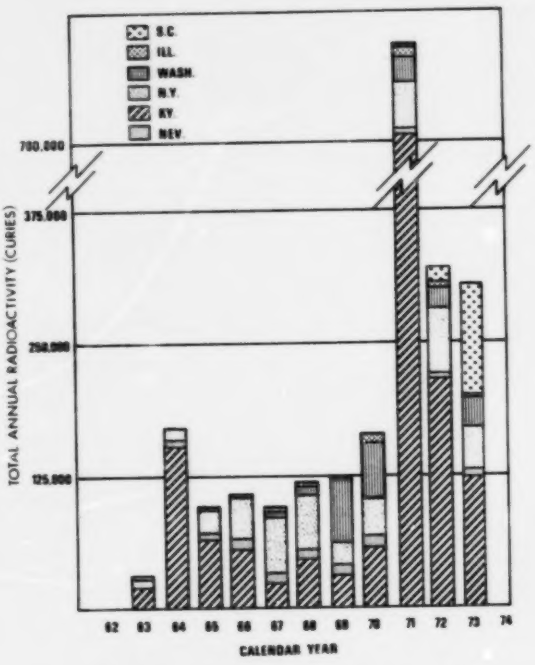

Figure 2. Total curies of byproduct material at commercial sites in the United States

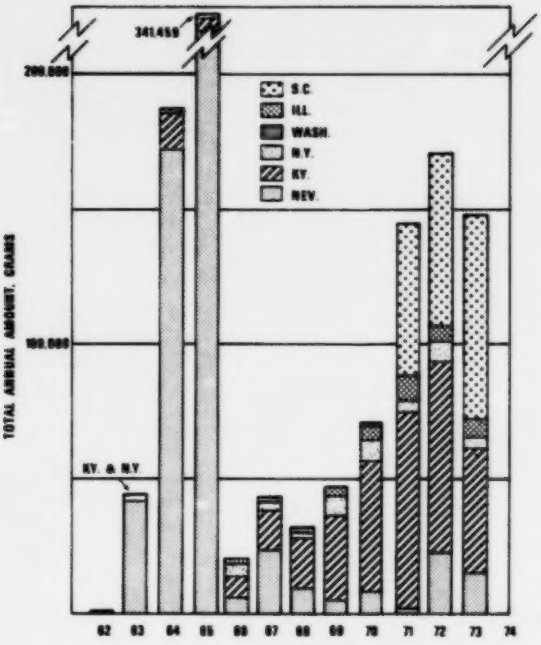

Figure 3. Total grams of special nuclear material buried at commercial sites in the United States

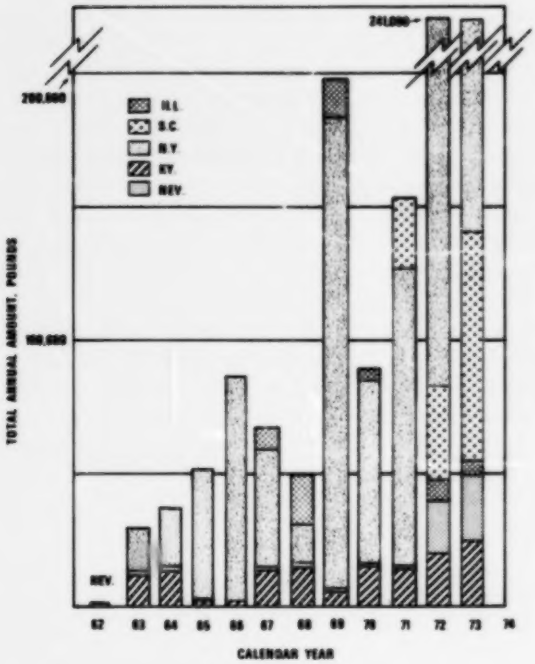

Figure 4. Total pounds of source material buried at commercial sites in the United States (Washington State data not included)

surized water reactors and 0.89 Ci/cubic foot from boiling water reactors (*6*).

The waste input to sites in the western United States (Nevada and Washington) has not been as large as the waste input to the other sites. This may reflect the fact that commercial nuclear power development in these regions has not been as rapid as elsewhere in the United States. Whereas the Kentucky, Illinois, New York, and South Carolina sites show either large quantities or increases in quantities from 1970 onward, probably because of the growth of nuclear power in these regions; the western sites have continued to receive lesser quantities of wastes at a level consistent with the steady contribution from isotope manufacturers, radiopharmaceutical firms, and research facilities. This trend is likely to change as nuclear power becomes more significant in the western United States.

Figure 3 illustrates the variable quantities of SNM being buried. Because this type of waste often contains significant quantities of transuranium elements (those elements with an atomic number greater than 92), it is expected that the future may show decreasing amounts of SNM at particular sites and perhaps increases at others. This shifting of the destination of transuranic-contaminated waste may well be the result of the exclusion of SNM wastes exceeding 10 nCi/g of transuranics at the three eastern sites. The prohibition of transuranic waste burial at the Barnwell, S.C. facility is part of the State license agreement made in 1971. As of 1974, the States of Kentucky and New York and their burial facility contractors have notified their customers that they will no longer accept transuranic wastes. In the near future, it is possible that all waste materials exceeding 10 nCi/g contamination with transuranics will be taken to an AEC-controlled site for disposition based on the U.S. AEC draft environmental impact statement, "Management of Commercial High Level and Transuranium-Contaminated Radioactive Waste". (*7*).

The total weight of source material buried has increased greatly since 1968, as shown in figure 4. The site in New York receives the largest proportion of this waste, possibly because of the close proximity of the Nuclear Fuel Services (NFS) nuclear fuel reprocessing plant. The growth in the production of such waste is inevitable as the commercial nuclear industry continues to expand. Future generation of these low-level radioactive wastes will probably be distributed to the burial sites which are located closest to the various nuclear facilities because of the economic advantage of minimizing trucking distances.

Figure 5 demonstrates the impact on burial site operations when changes in burial site regulations are instituted. Liquid wastes were transported and stored onsite until solidified for burial at three sites (Kentucky, Nevada, and Washington) until 1972, when the States and site contractors initiated requirements for the solidification of these wastes prior to shipment to the burial sites. Both the waste generators and site operators use a variety of solidification methods such as sorption on vermiculite and mixing with concrete, paper, or other special compounds. This regulatory action, which will eliminate the shipment of liquids to the commercial sites may result in a corresponding increase in the volume of solid waste going to the burial sites. This factor may have contributed, in part, to the increases in volume observed in figure 1 during the 1971–1973 period.

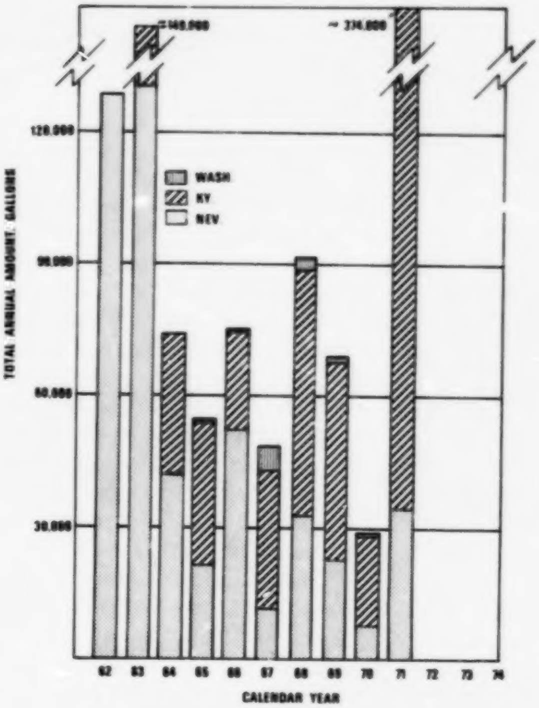

Figure 5. Total gallons of liquid wastes received at commercial sites in the United States

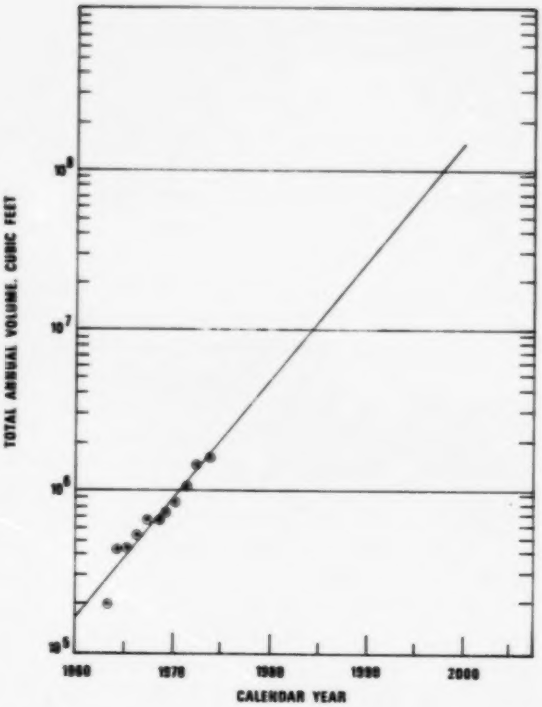

Figure 6. Volume of solid wastes buried annually

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Figure 6 contains a plot of the national annual volumes (from table 1) of waste buried at the commercial burial sites between 1963 and 1973 and a projection to the year 2000. This projection represents the total uncompacted volume of waste from fuel cycle and nonfuel cycle sources and is extrapolated from the volume buried between 1963 and 1973 rather than from nuclear power growth projections. However, the nuclear power growth factor is included in the regionalization and site capacity projections discussed in the following paragraphs.

It has been estimated by the years, 1980, 1985, and 2000, the uncompacted waste from nonfuel cycle sources will be approximately 44, 27, and 14 percent of the total wastes being buried as low-level waste for each respective year (*8*). Table 6 presents average values of the projected volumes shown in figure 6, using the above percentages to calculate the average contribution of the nonfuel cycle portion of the total wastes estimated.

Table 6. Projected average annual volume of low-level waste (10^6 cubic feet yr)

Type	1976–1980	1981–1990	1991–2000
Fuel cycle waste	2.0	10.6	68.0
Nonfuel cycle waste[a]	1.6	3.9	11.0
Total[b]	3.6	14.5	79.0

[a] From reference *8*.
[b] From figure 6.

Regionalization and site capacities

Although previous projections have been made of the quantity of low-level waste that will result from the fuel cycle and nonfuel cycle sources, no previous attempt has been made to relate the projections to the available capacity of the commercial sites. Therefore, a number of suppositions are made in the following paragraphs to speculate on what the impact might be on the present commercial burial sites if the projections indicated previously become valid. By arbitrarily dividing the continental United States into six geographic regions, and assuming that nuclear facilities within the region will send their radioactive waste to the regional burial ground, it is possible to allocate the national projected volume among the six existing sites.

In allocating the national annual volume of waste (table 6), the nuclear power electrical capacity within the region was used as the basis for the regional share of fuel cycle wastes, and an equal geographical distribution was assumed for nonfuel cycle generated wastes.

Based on reactor license applications, the AEC has periodically published projections of nuclear power generating capacity for the United States (*9*). Figure 7, shows the six regions which are used for the projected allocations to each of the six sites. These boundaries are hypothetical and the assumptions and calculations made within this section do not have any political or regulatory significance. To extend the waste generation estimates beyond 1985, it was assumed that the nuclear plants planned beyond the 1985 AEC projections (shown in figure 7) would not significantly affect the relative regional power generating capacities. In table 7, the percentage of the national nuclear electrical capacity for each region is given, and the projected total annual volume of waste the region can expect to generate during the indicated time period is given in parentheses. The estimated annual volume includes both fuel cycle and nonfuel cycle generated wastes. Based on this assumption, it is possible to estimate the cumulative

Table 7. Regional percentage of national nuclear power capacity and estimated annual low-level radioactive waste generated in the region in the time period indicated

Region	Site	Volume (10^6 cubic feet/yr)		
		1976–1980	1981–1990	1991–2000
Northeastern	West Valley, N.Y	24% (0.7)	23% (3.1)	23% (17.4)
Middle Atlantic	Maxey Flats, Ky	16% (.6)	13% (2.0)	13% (10.7)
Southern	Barnwell, S.C	27% (.8)	28% (3.6)	28% (20.8)
Midwestern	Sheffield, Ill	23.5% (.7)	26.5% (3.5)	26.5% (19.9)
Southwestern	Beatty, Nev	5% (.4)	5.5% (1.2)	5.5% (5.6)
Northwestern	Richland, Wash	4.5% (.4)	4% (1.1)	4% (4.6)

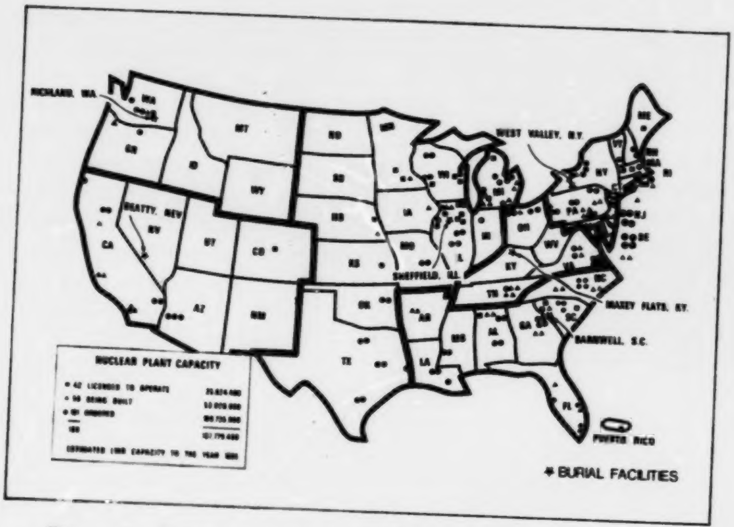

Figure 7. Location of commercial burial facilities and nuclear power reactors in the United States

volume of waste destined for each of the six arbitrary regions. This summation is presented in table 8.

Table 8. Estimated cumulative volume of waste generated in each region through the year indicated

Region	Volume (10^6 cubic feet)				
	1973[a]	1975[b]	1980[c]	1990[c]	2000[c]
Northeastern	2.0	2.9	6.4	37.4	211.4
Middle Atlantic	3.4	4.9	7.9	27.9	134.9
Southern	.8	1.1	5.1	41.1	249.1
Midwestern	1.0	1.4	4.9	39.5	238.5
Southwestern	1.5	2.1	4.1	16.1	72.1
Northwestern	.5	.7	2.7	13.7	59.7
National cumulative total	9.2	13.1	31.1	175.7	965.7

[a] Obtained from table 1.
[b] Calculated using figure 6 and the partitioning of waste based upon cumulative volume up to 1973.
[c] Obtained from table 7.

It is possible that the existing sites may not be able to satisfy the demand within each region. Therefore, a further assumption is made concerning the trench capacity and the estimated waste generation rate. A standard trench is assumed to be 300 feet long x 40 feet wide x 20 feet deep (240 000 cubic feet) with 20 feet of spacing between adjacent trenches. This standard trench will not be 100 percent filled with waste, but will contain voids. It is assumed that the top meter of the trench depth will not be used and that a 30 percent void space will exist for each trench, thereby reducing the effective burial volume to approximately 143 000 cubic feet per trench. Table 9 summarizes the capacities of the existing sites using the foregoing assumptions and the date by which their current capacity will be exhausted using the cumulative regional volumes from table 8.

Table 9. Regional site sizes, burial capacity, and date by which current capacity may be exhausted

Site	Size (acres)	Possible number of standard trenches onsite	Current burial capacity (cubic feet)	Date current capacity may be exhausted
West Valley, N.Y	22	50	7.2×10^6	1981
Maxey Flats, Ky	330	750	1.1×10^8	1998
Barnwell, S.C	270	614	8.8×10^7	1993
Sheffield, Ill	22	50	7.2×10^6	1981
Beatty, Nev	80	182	2.6×10^7	1992
Richland, Wash	100	227	3.2×10^7	1994

The operational lifetime of each site depends upon the rate at which waste is received, site size, land availability for site expansion, and operational practices. The results, as shown in table 9, indicate that the current burial capacity of all six existing sites will be filled by 1998. Therefore, based on the waste generation rate projection, the existing sites will have to be closed or enlarged, or new sites will have to be established if enlargement is not possible because of geographical, topographical, or geological limitations.

Reducing the volume of the estimated wastes to be buried by compaction is one method available for extending the usefulness of a site. From a report describing AEC-managed waste, a reduction in volume by a factor from 3 to 5 is possible (*10*). Therefore, if such volume reduction methods were instituted on all waste being sent to these burial sites, only two facilities, West Valley and Sheffield, would be filled before the year 2000.

Conclusion

The primary purpose of this report is to present the inventory data accumulated by this agency during the past few years, to point out some of the more obvious trends, and to identify and focus attention on the possible magnitude of the low-level radioactive waste disposal problem with which we may be faced in the near future. The data presented indicate that the volume and quantity of low-level waste is growing rapidly.

Based on these data, the assumptions, estimates and projections made about the existing commercial burial facilities indicate that two of the sites could be filled by 1985 and all six of the present sites could be filled by 1998 if no changes to the present practices or trends occur. Therefore, indicate that since a significant time period will be required for planning, evaluation, and licensing of any new burial sites, or for any significant expansion of existing sites, it is imperative that a more detailed analysis of low-level waste management activities than attempted in this report be completed.

Acknowledgment

The U.S. Environmental Protection Agency's Office of Radiation Programs expresses its appreciation to the State agencies submitting the data and to the reviewers, G. L. Meyer and J. E. Dieckhoner, who made significant contributions to the preparation of this report.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, July 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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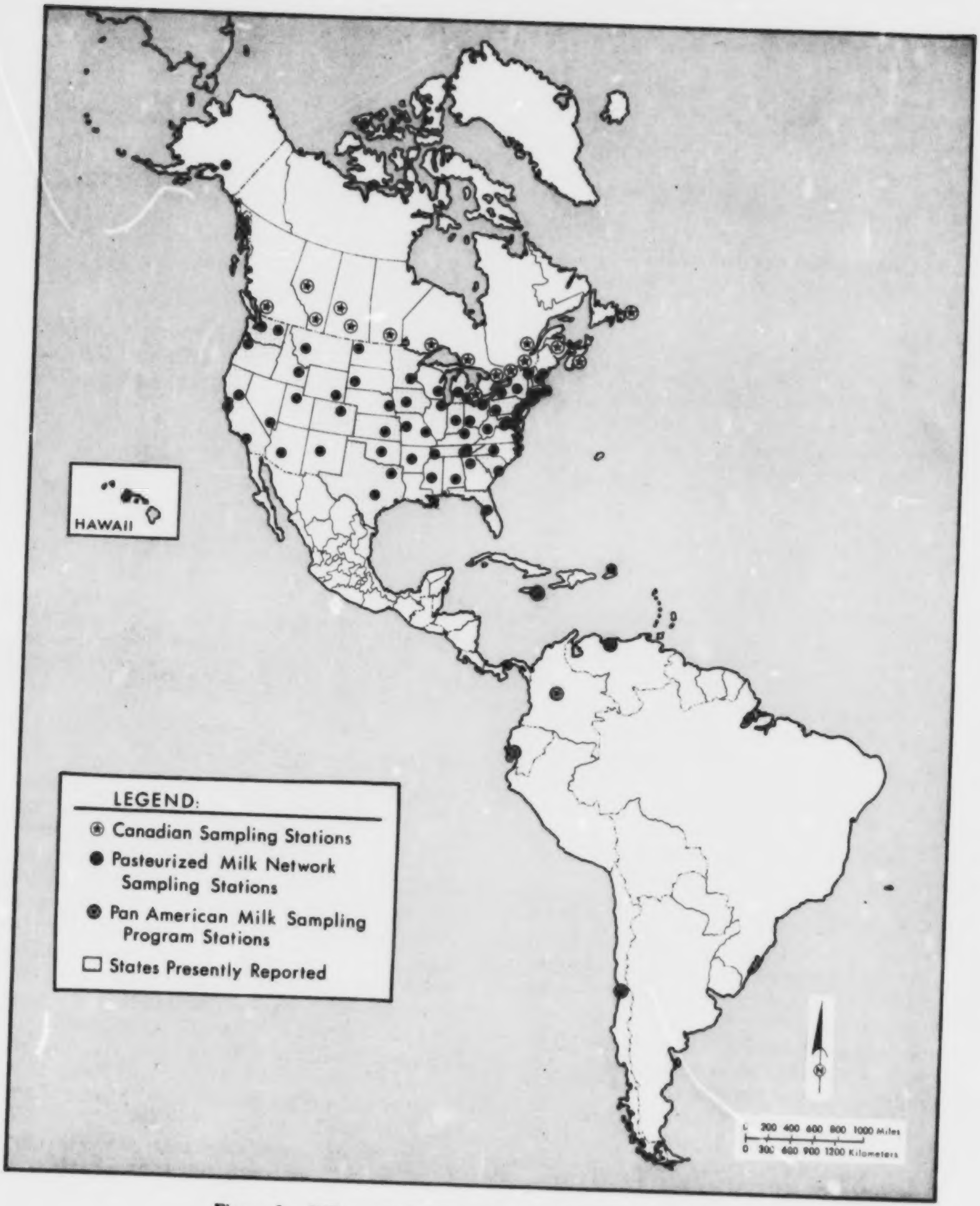
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reported in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131:	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137:	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89:	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90:	(32.1 or 32.4 (pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw milk and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard deviation total analytical replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports*.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the

Table 2. Concentrations of radionuclides in milk for July 1974 and 12-month period, August 1973 through July 1974

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	4	4	11	2
Alaska:	Palmer [c]	P	NS	NA	NS	3
Ariz:	Phoenix [c]	P	0	0	0	1
Ark:	Little Rock [c]	P	9	9	16	5
Calif:	Los Angeles [c]	P	0	0	0	0
	Sacramento [c]	P	0	0	0	2
	San Francisco [c]	P	0	0	0	0
	Del Norte	P	12	9	0	4
	Fresno	P	0	1	0	0
	Humboldt	P	2	2	0	0
	Los Angeles	P	2	1	0	2
	Mendocino	P	0	2	0	2
	Sacramento	P	2	2	0	2
	San Diego	P	0	1	0	2
	Santa Clara	P	0	1	0	2
	Shasta	P	3	2	0	2
	Sonoma	P	2	2	0	3
Colo:	Denver [c]	P	3	3	11	1
	East	R	NS		NS	
	Northeast	R	NA		[d] 0	0
	Northwest	R	NA		[d] 0	0
	South Central	R	NS		NS	
	Southeast	R	NS		NS	0
	Southwest	R	NS		[d] 0	0
	West	R	NS		NS	0
Conn:	Hartford [c]	P	5	5	14	3
	Central	P	NA		NA	
Del:	Wilmington [c]	P	5	5	0	1
D.C:	Washington [c]	P	5	5	0	1
Fla:	Tampa [c]	P	NS		NS	24
	Central	R	NA		NA	
	North	R	NA		NA	
	Northeast	R	NA		NA	
	Southeast	R	NA		NA	
	Tampa Bay area	P	NA		NA	
	West	R	NA		NA	
Ga:	Atlanta [c]	P	5	5	14	4
Hawaii:	Honolulu [c]	P	0	0	0	0
Idaho:	Idaho Falls [c]	P	3	3	0	0
Ill:	Chicago [c]	P	6	6	15	1
Ind:	Indianapolis [c]	P	5	5	12	3
	Central	P	8	5	15	5
	Northeast	P	8	6	10	10
	Northwest	P	8	7	15	8
	Southeast	P	7	6	10	8
	Southwest	P	9	7	0	5
Iowa:	Des Moines [c]	P	5	5	12	1
	Des Moines	P	5	4	0	0
	Iowa City	P	7	6	0	0
	LeMars	P	4	4	0	0
	Little Cedar	P	8	6	0	0
Kans:	Wichita [c]	P	7	7	0	2
	Coffeyville	P	8	6	NA	7
	Dodge City	P	3	4	NA	7
	Falls City, Nebr	R	3	5	NA	8
	Hays	P	7	6	NA	5
	Kansas City	P	0	4	NA	5
	Topeka	P	4	6	NA	6
Ky:	Louisville [c]	P	4	4	11	4
La:	New Orleans [c]	P	9	9	12	6
Maine:	Portland [c]	P	6	6	20	11
Md:	Baltimore [c]	P	5	5	13	4
Mass:	Boston [c]	P	8	8	18	4
Mich:	Detroit [c]	P	6	6	12	4
	Grand Rapids [c]	P	8	8	13	1
	Bay City	P	12	10	0	3
	Charlevoix	P	11	9	0	0
	Detroit	P	4	9	13	1
	Grand Rapids	P	13	14	0	5
	Lansing	P	7	11	0	3
	Marquette	P	11	12	19	6
	Monroe	P	10	13	0	2
	South Haven	P	9	14	0	2
Minn:	Minneapolis [c]	P	9	9	15	1
	Bemidji	P	7	10	0	0
	Duluth	P	23	15	34	15
	Fergus Falls	P	5	6	0	0
	Little Falls	P	23	17	43	45
	Mankato	P	5	5	0	0
	Marshall	P	NS	3	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1974 and 12-month period, August 1973 through July 1974—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:	Minneapolis	P	8	9	0	0
	Rochester	P	6	6	0	0
Miss:	Jackson [c]	P	7	7	12	3
Mo:	Kansas City [c]	P	3	3	0	0
	St. Louis [c]	P	5	5	13	2
Mont:	Helena [c]	P	0	0	0	0
Nebr:	Omaha [c]	P	4	4	0	1
Nev:	Las Vegas [c]	P	0	0	0	0
N.H:	Manchester [c]	P	8	8	20	5
N.J:	Trenton [c]	P	NS	NA	NS	1
N. Mex:	Albuquerque [c]	P	0	0	0	0
N.Y:	Buffalo [c]	P	4	4	0	0
	New York City [c]	P	9	9	11	2
	Syracuse [c]	P	5	5	15	4
	Albany	P	7	5	0	0
	Buffalo	P	9	5	0	0
	Massena	P	10	7	17	0
	New York City	P	NA	6	0	0
	Syracuse	P	13	6	11	0
N.C:	Charlotte [c]	P	5	5	0	4
	Asheville	P	7		0	
	Charlotte	P	7		0	
	Lexington	P	NA		NA	
	New Bern	P	7		0	
	Raleigh	P	7		0	
	Wilkesboro	P	11		21	
N. Dak:	Minot [c]	P	7	7	0	1
Ohio:	Cincinnati [c]	P	7	7	11	4
	Cleveland [c]	P	5	5	0	0
Okla:	Oklahoma City [c]	P	7	7	0	1
Oreg:	Portland [c]	P	0	0	0	0
	Coos Bay	P	NA		[d] 0	0
	Eugene	P	NA		15	5
	Medford	P	NA		[d] 0	0
	Portland composite	P	NA		[d] 0	0
	Portland local	P	NA		[d] 0	1
	Redmond	P	NA		[d] 0	3
	Tillamook	P	NA		[d] 0	5
Pa:	Philadelphia [c]	P	5	5	0	1
	Pittsburgh [c]	P	8	8	0	2
	Dauphin	P	5	4	0	0
	Erie	P	6	6	0	0
	Philadelphia	P	5	5	0	0
	Pittsburgh	P	8	6	0	0
R.I:	Providence [c]	P	5	5	19	6
S.C:	Charleston [c]	P	5	5	14	8
	Anderson–01	R	NS	7	NS	2
	Anderson–02	R	NS	6	NS	3
	Chapin	R	8	7	0	8
	Clemson	R	NS	7	NS	4
	Columbia	R	8	8	0	10
	Fairfield	R	7	6	0	11
	Hartsville–02	R	NS	6	NS	10
	Hartsville–03	R	NS	13	NS	13
	Lee County	R	NS	7	NS	10
	Oconee County	R	NS	7	NS	5
	Pickens	R	NS	7	NS	9
	Williston	R	NS	7	NS	15
	Winnsboro	R	6	6	12	14
	York–01	R	NS	7	NS	5
	York–02	R	NS	5	NS	0
S. Dak:	Rapid City [c]	P	NS	NA	NS	0
Tenn:	Chattanooga [c]	P	6	6	11	4
	Knoxville [c]	P	6	6	0	3
	Memphis [c]	P	4	4	0	2
	Chattanooga	P	5	7	0	1
	Clinton	R	9	10	0	3
	Fayetteville	R	6	8	0	4
	Kingston	R	10	9	0	3
	Knoxville	P	11	9	0	4
	Lawrenceburg	R	27	9	0	0
	Nashville	P	8	8	0	0
	Pulaski	R	9	7	0	0
	Sequoyah	R	NS	9	NS	0
Tex:	Austin [c]	P	0	0	0	0
	Dallas [c]	P	5	5	0	1
Utah:	Salt Lake City [c]	P	0	0	0	0
Vt:	Burlington [c]	P	7	7	13	3
Va:	Norfolk [c]	P	5	5	0	1
Wash:	Seattle	P	4	4	0	3
	Spokane [c]	P	5	5	11	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1974 and 12-month period, August 1973 through July 1974—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash:	Benton County	R	0	0	0	0
	Franklin County	R	NS	0	NS	0
	Longview	R	5	6	0	7
	Sandpoint, Idaho	R	4	5	0	1
	Skagit County	R	8	5	0	2
W. Va:	Charleston [c]	P	7	7	12	2
Wisc:	Milwaukee [c]	P	4	4	0	0
Wyo:	Laramie [c]	P	2	2	0	0
CANADA:						
Alberta:	Calgary	P	4	4	0	5
	Edmonton	P	5	5	0	8
British Columbia:	Vancouver	P	7	6	13	11
Manitoba:	Winnipeg	P	4	4	13	8
New Brunswick:	Moncton	P	6	6	NS	8
Newfoundland:	St. John's	P	9	10	10	12
Nova Scotia:	Halifax	P	6	6	0	7
Ontario:	Ottawa	P	4	4	0	5
	Sault Ste. Marie	P	8	8	19	13
	Thunder Bay	P	6	6	13	9
	Toronto	P	3	4	0	5
	Windsor	P	3	2	NS	5
Quebec:	Montreal	P	4	5	0	4
	Quebec	P	7	7	0	12
Saskatchewan:	Regina	P	5	4	0	4
	Saskatoon	P	5	5	NS	5
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal [c]	P	0	0	0	0
Chile:	Santiago	P	NS	0	NS	3
Colombia:	Bogota	P	0	1	0	0
Ecuador:	Guayaquil	P	0	1	0	2
Jamaica:	Kingston	P	NS		NS	
Puerto Rico:	San Juan [c]	P	0	0	0	2
Venezuela:	Caracus	P	0	0	0	0
PMN network average [e]			4	4	6	2

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling station result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appro-

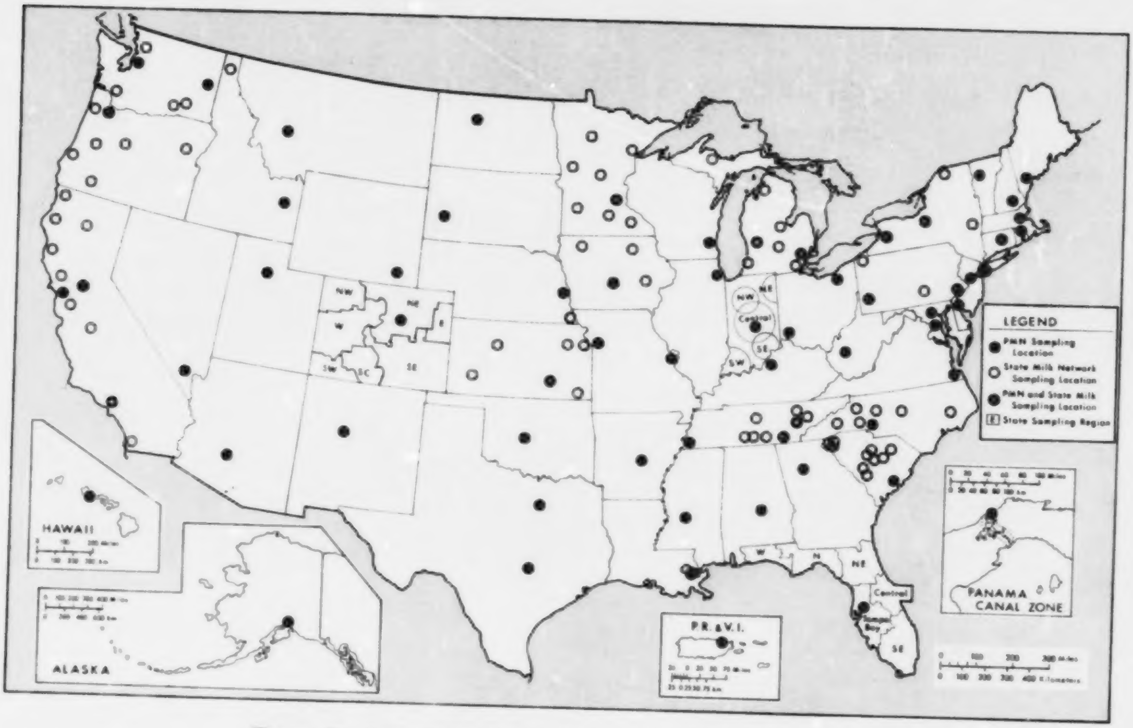
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
SW
SC
SE
Central
Tampa Bay
N

Figure 2. State and PMN sampling stations in the United States

priate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for July 1974 and the 12-month period, August 1973 to July 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for June 1974 were below the respective practical reporting levels. The following station average reflects a sample in which strontium-89 was detected: Colombia: Bogota, 14 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 27 pCi/liter in the United States for July 1974 and the highest 12-month average was 17 pCi/liter (Little Falls, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 43 pCi/liter in the United States for July 1974, and the highest 12-month average was 45 pCi/liter (Little Falls, Minn.) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in the future.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Unit
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Division of Radiological Health
Indiana State Board of Health

State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa

Radiation Control Program
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Radiological Health
Michigan Department of Public Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York Department of Environmental Conservation

Radiation Protection Branch
Division of Facility Services
North Carolina Department of Human Resources

Radiological Control Section
Environmental Radiation Surveillance Program
Oregon Department of Human Resources

Radiological Health Section
Bureau of Radiological Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and Environmental Control

Division of Occupational and Radiological Health
Tennessee Department of Public Health

Radiation Control Unit
Division of Health
Washington Department of Social and Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

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(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network,[1] Third Quarter 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Milk Surveillance Network, operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and 1 alternate sampling location (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS).

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional milk sampling net-

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

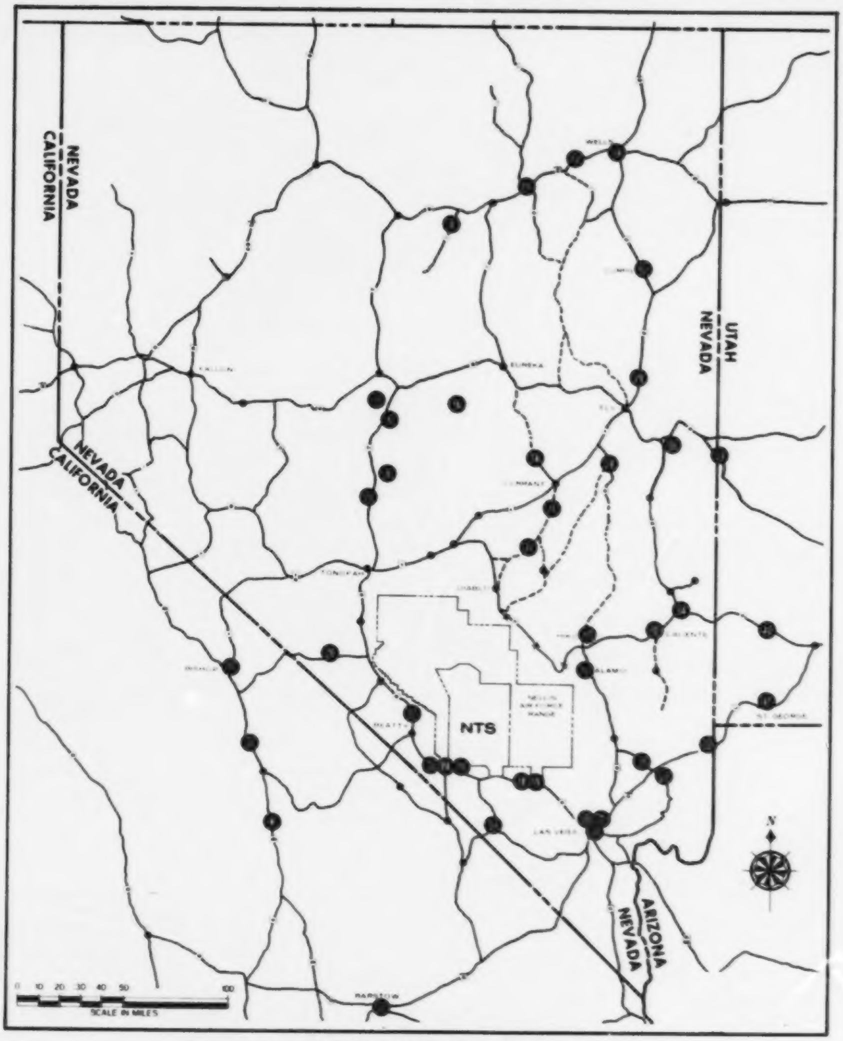
NEVADA
CALIFORNIA
UTAH
NEVADA
WELLS
EUREKA
ELY
FALLON
CURRANT
TONOPAH
HIKO
CALIENTE
ALAMO
BISHOP
BEATTY
NTS
NELLIS AIR FORCE RANGE
ST. GEORGE
LAS VEGAS
ARIZONA
NEVADA
N
0 10 20 30 40 50 100
SCALE IN MILES
BARSTOW

Figure 1. NERC-LV Milk Surveillance Network

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works are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports*.

Results

The analytical results of all milk samples collected in the third quarter of 1974 by NERC-LV are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable concentration (MDC) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in the third quarter. Levels of tritium near the MDC for this radionuclide (200 pCi/liter) were also measured by liquid scintillation counting techniques. The highest concentrations of cesium-137 and tritium during the third quarter were 25 pCi/liter and 560 ± 230 pCi/liter, respectively.

Table 1. Milk surveillance results, July-September 1974

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Creamery	7/2	11	<10	<2.0	<1.2	NA
Hinkley:						
Bill Nelson Dairy	7/2	12	<10	<1.8	1.4 ±1.0	NA
Olancha:						
Hunter Ranch	7/2	13	<10	<1.9	<1.1	NA
Nevada:						
Alamo:						
Williams Dairy	7/10	12	<10	<1.6	<1.0	NA
Austin:						
Young's Ranch	7/16	13	<10	<2.0	<1.5	560 ±230
Currant:						
Blue Eagle Ranch	7/10	13	25	<1.8	1.1 ±1.1	NA
Manzonie Ranch	7/11	13	<10	<2.1	1.6 ±1.3	NA
Hiko:						
Schofield Dairy	7/10	12	<10	<1.8	<1.1	430 ±230
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	7/2	12	<10	<1.4	1.7 ±1.1	270 ±210
Lathrop Wells:						
Kirker Ranch	7/19	13	<10	<2.0	<1.1	NA
Lida:						
Lida Livestock Company	7/15	13	<10	<2.0	<1.2	NA
Logandale:						
Vegas Valley Dairy	7/15	12	<10	<2.2	3.6 ±1.4	NA
Lund:						
McKenzie Dairy	7/17	12	<10	<2.0	<1.3	<220
Mesquite:						
Hughes Bros. Dairy	7/16	12	<10	<1.6	<1.0	<230
Moapa:						
Searles Dairy	7/15	12	<10	<1.7	<1.1	NA
Nyala:						
Sharp's Ranch	7/11	13	<10	<1.5	1.6 ±1.0	340 ±220
Pahrump:						
Burson Ranch	7/18	13	<10	<1.6	<1.0	NA
Panaca:						
Kenneth Lee Ranch	7/8	13	<10	<2.0	< .93	NA
Round Mountain:						
Berg Ranch	NS					
Shoshone:						
Kirkeby Ranch	7/15	13	<10	<2.3	3.8 ±1.5	NA
Springdale:						
Seidentopf Ranch	7/11	13	<10	<2.0	<1.2	NA
Utah:						
Cedar City:						
Western Gold Dairy	7/18	12	<10	<2.2	<1.4	NA
St. George:						
R. Cox Dairy	7/17	12	<10	<2.0	<1.3	NA

[a] 11—pasteurized milk.
12—raw milk from Grade A producer(s).
13—raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973

Strontium-90 in Tri-City Diets,[1] January-December 1973

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (*HASL*). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

In 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*3*). The changes in the composition of the diet from

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[1] Data from Fallout Program Quarterly Summary Report, HASL 276, 278, 281, 284. Available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, January-June 1973

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90							
			New York City February 1973		San Francisco March 1973		New York City May 1973		San Francisco June 1973	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	6.6	1 326	1.6	315	4.0	800	0.6	120
Fresh fruit	59	9.4	16.0	941	2.6	156	12.5	740	3.0	177
Fresh vegetables	48	18.7	11.7	564	2.2	103	15.3	733	4.7	224
Root vegetables	10	3.8	7.0	70	3.6	36	5.1	51	2.6	26
Potatoes	38	3.8	6.8	260	3.2	121	5.2	196	1.1	43
Macaroni	3	.6	4.2	13	3.2	10	4.2	12	2.7	8
Rice	3	1.1	1.4	4	2.0	6	3.0	9	.6	2
Fruit juices	28	2.5	3.1	86	1.8	49	2.8	79	1.3	38
Canned vegetables	22	4.4	6.6	145	4.5	100	10.1	222	4.4	97
Canned fruit	11	.6	1.1	13	1.9	21	.9	10	.6	7
Dried beans	3	2.1	5.9	18	19.4	58	9.9	30	6.3	19
Flour	34	6.5	5.6	190	3.7	126	5.0	168	3.3	112
Bakery products	44	53.7	4.0	177	3.0	134	4.6	203	2.4	105
Whole grain products	11	10.3	9.4	104	7.3	80	9.4	103	5.0	55
Fresh fish	8	7.6	.1	1	.4	3	.6	5	.4	3
Shell fish	1	1.6	1.0	1	.3	0	1.5	1	.6	1
Poultry	20	6.0	.7	15	.3	7	.6	11	.3	6
Meat	79	12.6	.4	33	ND		.6	44	.3	20
Eggs	15	8.7	1.4	21	.7	10	2.5	37	1.1	17
Annual intake (pCi/a)		370		3 982		1 335		3 454		1 080
Daily intake (pCi/g Ca)				10.8		3.6		9.3		2.9

ND, nondetectable.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet, July-December 1973

Food category	Diet (kg/a)	Calcium (g/a)	Strontium-90							
			New York City August 1973		San Francisco September 1973		New York City November 1973		San Francisco December 1973	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	6.0	1 210	1.4	285	5.1	1 023	1.3	262
Fresh fruit	59	9.4	2.2	132	1.8	106	13.3	787	1.9	110
Fresh vegetables	48	18.7	9.7	465	1.9	90	15.5	745	2.1	99
Root vegetables	10	3.8	7.4	74	3.0	30	8.9	89	3.3	33
Potatoes	38	3.8	3.5	132	1.5	57	6.5	249	5.1	193
Macaroni	3	.6	3.5	10	2.9	9	3.4	10	2.5	7
Rice	3	1.1	1.0	3	1.7	5	1.4	4	1.3	4
Fruit juices	28	2.5	3.2	88	1.3	35	3.1	87	1.7	49
Canned vegetables	22	4.4	8.5	187	3.6	80	9.5	209	4.7	103
Canned fruit	11	.6	1.4	16	.9	9	1.1	12	.9	10
Dried beans	3	2.1	28.0	84	22.3	67	23.0	69	10.9	33
Flour	34	6.5	6.2	211	1.7	58	5.2	176	2.6	87
Bakery products	44	53.7	3.7	163	2.3	102	4.5	196	2.5	111
Whole grain products	11	10.3	7.3	81	6.0	66	7.8	86	4.2	46
Fresh fish	8	7.6	1.8	15	.2	1	.4	3	.6	5
Shell fish	1	1.6	.7	1	.4	—	1.4	1	.9	1
Poultry	20	6.0	.8	16	.4	9	.6	12	.5	10
Meat	79	12.6	.5	42	.3	21	.8	63	.4	35
Eggs	15	8.7	.6	9	.6	9	1.5	22	.9	14
Annual intake (pCi/a)		370		2 939		1 039		3 843		1 212
Daily intake (pCi/g Ca)				7.9		2.8		10.4		3.3

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1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1973 in New York City and San Francisco.

Results for January–December 1974 are presented in tables 1 and 2. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

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(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J. and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-137. Office of Technical Services, U.S. Atomic Energy Commission, New York, N.Y. (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965, A Preliminary Report. USDA, ARS 62-16 (August 1967).

Previous coverage in Radiation Data and Reports:

Period	Issue
January–December 1972	December 1973

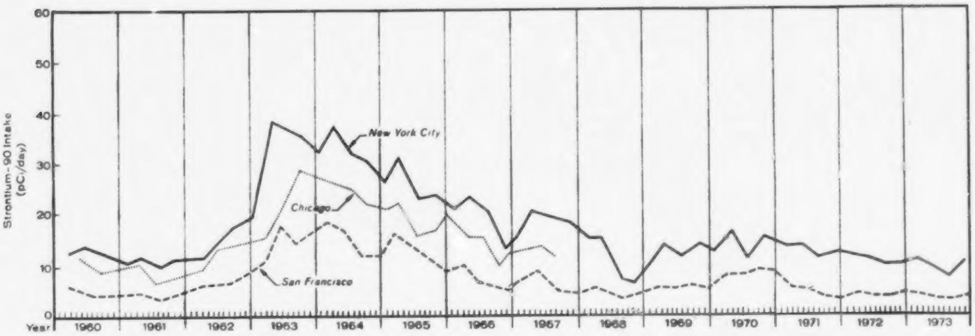

Figure 1. Daily intake of strontium-90 in tri-city diets, 1960-December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, *HASL*	1972	December 1973
Washington	July 1971–June 1972	October 1974

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Interstate Carrier Drinking Water Analysis Program, 1972

Office of Water Operations and
Office of Radiation Programs
Environmental Protection Agency

The routine surveillance of finished drinking water from public drinking water supplies is a project of the Office of Water Program Operations of the Environmental Protection Agency (EPA), in partial fulfillment of the requirements as set forth in Subpart J of the Interstate Quarantine Regulation (*1*) most commonly referred to as the Public Health Service Drinking Water Standards. The basic network for this activity is the approximately 700 water supplies (serving over half of the U.S. population with access to public water systems) which provide water for use by interstate carriers. Laboratory support is provided by the Eastern Environmental Radiation Facility and the Office of Radiation Programs—Las Vegas Facility. All samples were taken either as a single grab sample or composite samples taken over 12 to 14 days and the results of the radiological analyses are shown in table 1. In many cases where a water system receives raw water from more than one source, the finished drinking water derived from each source has been examined.

The drinking water standards for radionuclides are conservative in their requirements so that the total intake of these radionuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium-226 nor 10 pCi/liter of strontium-90. In the absence of strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentration does not exceed 1000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance for control action recommended by the Federal Radiation Council. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

Other coverage in Radiation Data and Reports:

Period	Issue
1961–1966	August 1968
1967–1969	December 1970
1970	July 1971
1971	May 1972

REFERENCES

(*1*) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards: 2154–2155 (March 6, 1962).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, (September 1961).

Table 1. Radiological analysis of interstate carrier water supplies, 1972[a]

Sample location		Date collected (1972)	Gross alpha (pCi /liter ± 2σ)	Gross beta (pCi /liter ± 2σ)	Radium-226 (pCi /liter ± 2σ)	Strontium-90 (pCi /liter ± 2σ)
Ala:	Birmingham	8/17– 8/30	0	0		
		8/17– 8/30	0	2 ± 1		
		8/31	0	0		
		8/18– 8/31	0	0		
		8/18– 8/31	0	4 ± 1		
		8/18– 8/31	0	0		
		8/18– 8/31	0	0		
		8/31	0	0		
		8/31	0	0		
Colo:	Antonito	7/18	0	0		
Conn:	Bridgeport	8/ 7	0	5 ± 1		
		8/ 7	0	5 ± 1		
		8/ 8	0	4 ± 1		
		8/ 8	0	3 ± 1		
		8/8	0	3 ± 1		
		8/ 8– 8/21	0	3 ± 1		
		8/ 8– 8/21	0	0		
		8/ 8– 8/21	0	3 ± 1		
		8/24	0	0		
	Danbury	9/27–10/10	0	3 ± 1		
		9/27–10/11	0	0		
	Groton	6/ 8– 6/21	0	4 ± 1		
	New Haven	11/14	0	0		
		11/14	0	0		
		11/14	0	0		
		11/13–11/26	0	3 ± 1		
		11/13–11/26	0	0		
		11/14–11/27	0	0		
		11/14–11/27	0	2 ± 1		
		11/14–11/27	0	0		
		11/20–12/ 3	0	3 ± 1		
		11/20–12/ 3	0	2 ± 1		
		11/20–12/ 3	0	4 ± 1		
	New London	6/ 7– 6/20	0	5 ± 1		
	Stamford	11/ 1–11/14	0	4 ± 1		
		11/ 1–11/14	0	4 ± 1		
	Waterbury	6/27– 7/10	0	4 ± 1		
		6/27– 7/10	0	4 ± 1		
	Windsor Locks	8/22	0	3 ± 1		
		8/22	0	0		
		8/22	0	0		
		8/22	0	0		
Ill:	Bedford Park	5/ 8	0	3 ± 1		
	Harrisburg	7/14	0	7 ± 2		
	Hartford	7/12	0	4 ± 1		
	Joilet	5/16	16 ± 4	32 ± 3	4.6 ± 0.1	0
		5/17	12 ± 6	25 ± 3	2.7 ± .1	0
	Lemont	5/ 9	18 ± 8	27 ± 3	8.7 ± .1	0
	Orland Park	5/10	4 ± 4	4 ± 1		
	Peoria	7/11	0	8 ± 2		
Ind:	East Chicago	12/13	0	4 ± 1		
	Logansport	12/12	0	3 ± 1		
Kans:	Wichita	9/26	0	4 ± 3		
		9/26	0	0		
La:	Boothville	6/29– 7/11	0	6 ± 3	.5 ± .2	
	Empire	6/28– 7/10	0	4 ± 3	.5 ± .2	
Mich:	Marine City	11/9	0	3 ± 1		
	Port Huron	11/8	0	2 ± 1		
N.J:	North Cape May	9/21	0	7 ± 2		
	Weehawken	4/ 4	0	3 ± 1		
N. Mex:	Albuquerque	8/29	4 ± 3	9 ± 3	.4 ± .2	
		9/ 1	10 ± 5	14 ± 4		0
N. Mex:	Roswell	10/17	0	0		
		10/17	0	0		
		10/17	0	0		
N.Y:	Lockport	10/10	0	4 ± 1		
	Niagara Falls	10/12	0	3 ± 1		
	Oneonta	11/28	0	0		
	White Plains	11/ 6	0	0		
Ohio:	Canton	8/22	0	0		
	Cincinnati	11/ 6	0	4 ± 1		
	Dayton	10/31	0	3 ± 1		
	Gallipolis	8/23	0	0		
P.R:	Guayama	12/ 7	0	0		
	Penuelas	12/11	0	0		
	Ponce	12/12	0	0		
Tex:	Pasadena	8/10	0	0		
	Texas City	8/10	0	7 ± 3		
Wash:	Bellingham	12/20	0	0		
	Ferndale	12/20	0	0		
	Longview	12/ 7	0	0		
Wash:	Port Angeles	7/26	0	0		
	Raymond	12/27	0	0		
Summary			0.8	3.2	[b] 2.9	[b] 0

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[a] The minimum detectable radioactivity is 2 pCi /liter for strontium-90, gross alpha, and gross beta radioactivity; and 0.1 pCi /liter for radium-226. All values equal to or less than the minimal detectable radioactivity are reported as 0.

[b] Average of only those samples analyzed.

Water Surveillance Network, Third Quarter 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the NTS.

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when re-

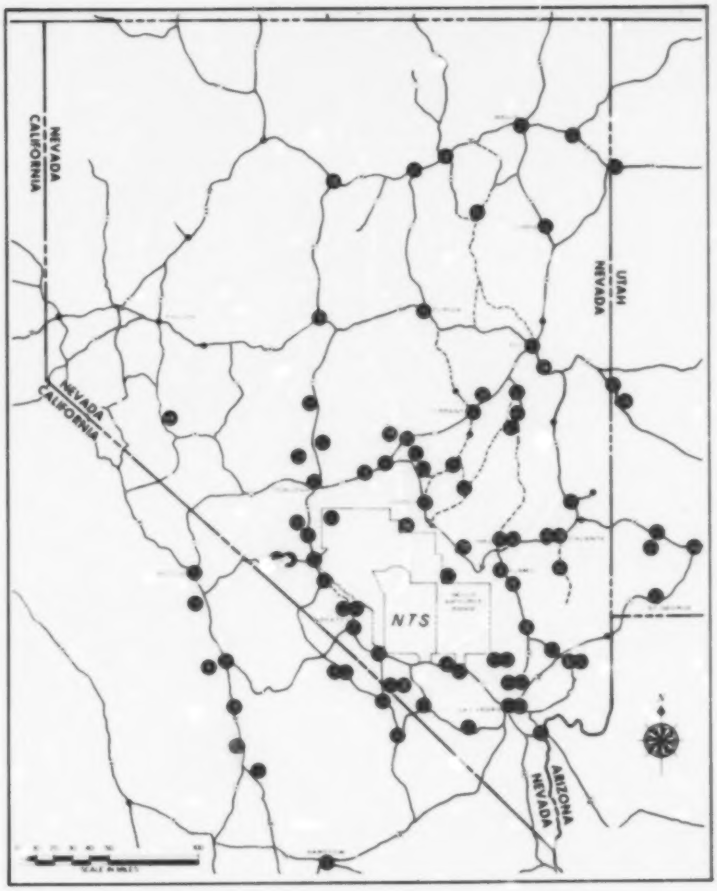

Figure 1. NERC-LV Water Surveillance Network

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[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Table 1. Water surveillance results, July 1974

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	7/2	23	<1.7	<2.9	NA
Death Valley Junction:					
Lila's Cafe	7/3	23	<6.2	9.0±3.5	<220
Furnace Creek:					
Pond	7/3	21	<3.6	9.3±3.5	NA
Visitors Center	7/3	27	<5.1	16 ±3.9	NA
Hinkley:					
Bill Nelson Dairy	7/2	23	7.3± 5.8	3.9±3.1	NA
Lone Pine:					
Forest Service Ranger Station	7/2	24	3.0± 2.6	3.6±3.0	NA
Olancha:					
Haiwee Reservoir	7/2	21	4.1± 3.3	3.8±3.0	NA
Ridgecrest:					
City Hall	7/2	23	<4.3	5.2±3.2	NA
Nevada:					
Adaven:					
Canfield Ranch	7/9	22	20 ± 8.4	25 ±4.4	NA
Alamo:					
Pahranagat Lake	7/8	21	<3.5	8.0±3.0	NA
Sheri's Bar	7/8	23	<3.1	8.1±3.0	NA
Williams Dairy	7/10	23	<4.4	13 ±3.7	NA
Austin:					
Nevada National Bank	7/16	27	<2.5	<3.1	NA
Blue Diamond:					
Post office	7/15	23	7.1±4.8	<3.0	<230
Blue Jay Highway:					
Maintenance Station	7/11	23	<3.8	6.7±3.2	NA
Cactus Springs:					
Mobil Service Station	7/8	27	<2.8	<2.9	<230
Caliente:					
Agricultural Extension Station	7/8	23	7.3± 5.2	6.7±3.3	NA
Clark Station:					
Five Mile Ranch	7/11	27	<2.4	7.2±3.3	NA
Currant:					
Currant Ranch Cafe	7/11	27	12 ± 6.5	6.4±3.3	NA
Diablo:					
Highway Maintenance Station	7/10	23	<3.1	6.8±3.2	NA
Reed Ranch	7/10	21	26 ± 8.6	30 ±4.6	NA
Elgin:					
Water tower	7/11	23	11 ± 6.6	8.1±3.4	NA
Ely:					
Chevron Service Station	7/16	24	4.0± 2.8	3.1±3.1	NA
Comins Lake	7/16	21	14 ± 6.0	29 ±4.6	NA
Eureka:					
Highway Maintenance Station	7/16	24	6.8± 3.7	4.1±3.2	NA
Goldfield:					
Chevron Service Station	7/15	23	3.9± 3.7	<3.2	NA
Hiko:					
Crystal Springs	7/9	27	4.1± 3.8	6.2±3.2	NA
Schofield Dairy	7/10	23	31 ± 9.9	40 ±5.1	NA
Las Vegas:					
Craig Ranch Golf Course	7/2	23	<3.5	5.2±3.1	<210
Desert Game Range	7/8	23	4.5± 3.4	<2.9	<220
Lab I NERC	7/2	24	<4.5	6.7±3.3	640±220
Lake Mead Vegas Wash	7/2	21	<4.7	8.9±3.5	800±220
L V Water District Well 28	7/2	23	3.7± 3.5	<3.0	<210
Municipal Golf Course	7/2	23	4.6± 3.7	<3.0	<210
Tule Springs	7/2	23	5.2± 3.5	4.0±3.0	350±220
Tule Springs Pond	7/8	23	2.9± 2.7	<2.9	NA
Vegas Estates	7/8	21	8.6± 6.1	11 ±3.6	<210
Lida:					
Lida Livestock Company	7/15	27	5.3± 3.5	<3.1	NA
Pond at storage tank	7/15	21	3.9± 2.9	<3.1	NA
Lund:					
Gardner Grocery	7/17	23	6.4± 3.6	<3.1	NA
Manhattan:					
Country store	7/17	23	21 ± 6.9	4.1±3.2	NA
Mesquite:					
Hughes Bros. Dairy	7/16	23	<3.7	4.6±3.7	NA
Moapa:					
Pedersen Valley View Ranch	7/16	27	<4.3	11 ±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	7/8	27	7.3± 5.8	<3.1	270±220
Nyala:					
Sharp's Ranch	7/11	23	4.7± 3.2	3.1±3.0	NA
Pahrump:					
Texaco Service Station	7/9	23	6.0± 3.7	3.1±3.0	NA
Pioche:					
County Courthouse	7/8	24	<3.1	7.7±3.3	NA
Round Mountain					
Mobil Service Station	7/16	27	2.8± 2.2	<3.1	NA
Scotty's Junction:					
Holloway Ranch	7/15	23	8.7± 5.2	9.6±3.6	<260

See footnotes at end of table.

Table 1. Water surveillance results, July 1974—continued

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Springdale:					
Pond	7/11	21	5.7 ± 5.3	8.7 ± 3.4	NA
Sunnyside:					
Adam McGill Reservoir	7/17	21	8.2 ± 4.1	6.4 ± 3.3	NA
Wildlife Management Headquarters	7/17	21	5.7 ± 3.2	6.8 ± 3.3	NA
Tonopah:					
Jerry's Chevron Station	7/11	23	<3.2	7.1 ± 3.2	NA
Tonopah Test Range CP-1	7/11	23	8.8 ± 5.4	6.5 ± 3.2	NA
Warm Springs:					
Fallini's Pond	NS				
Service Station and Cafe	7/11	27	35 ± 12	35 ± 4.9	NA
Twin Springs Ranch	7/11	23	8.9 ± 5.5	13 ± 3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	7/18	24	12 ± 2.6	11 ± 3.6	NA
St. George:					
R. Cox Dairy	7/18	24	4.8 ± 3.0	<3.1	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond; 22—Stream, river, creek; 23—Well; 24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring); and 27—Spring.

[b] Two-sigma counting error provided when available.

NA, not analyzed.

NS, no sample.

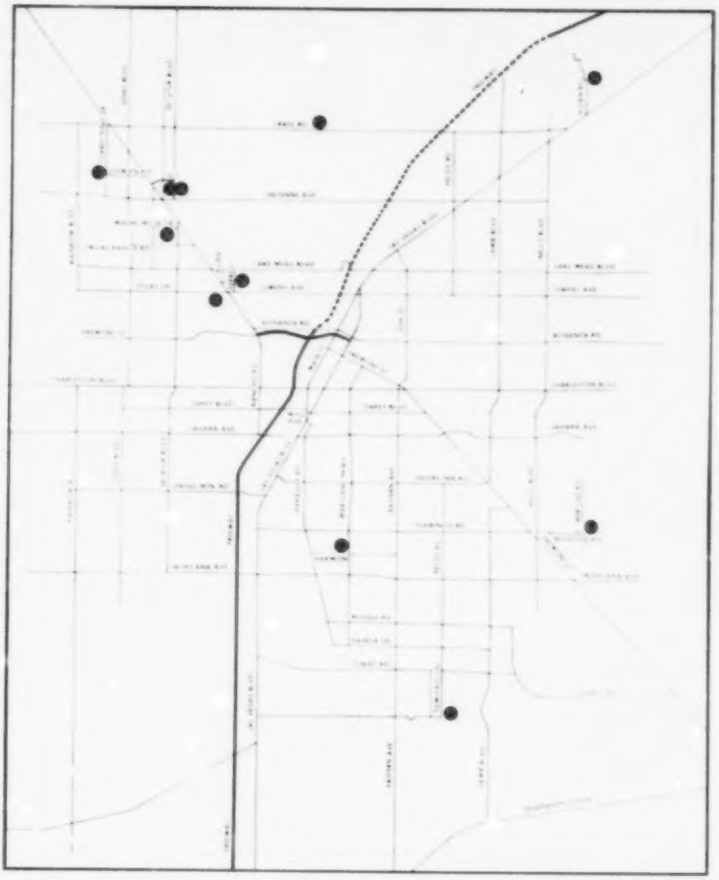

Figure 2. NERC-LV Water Surveillance Network—Las Vegas Valley

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Table 2. Special analytical results for water samples collected during 1974

Location	Date collected (1974)	Sample type ᵃ	Radionuclide concentrations ᵇ (pCi/liter)							
			^{89}Sr	^{90}Sr	^{226}Ra	^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
California:										
Bishop:										
Fish and Game Office	1/17	23	<3.0	<1.0	0.1 ±0.054	NA	NA	0.38±0.058	0.026±0.016	0.26 ±0.046
Death Valley Junction:										
Lila's Cafe	1/8	23	6.0±2.2	2.8± 1.4	.11 ± .060	NA	NA	6.4 ± .25	.082± .029	1.5 ± .12
Furnace Creek:										
Visitor's Center	1/8	27	<1.6	1.5 ±1.0	.23 ± .080	NA	NA	2.4 ± .14	.038± .020	.99 ± .090
Pond	1/8	21	<1.4	<.82	.16 ± .066	0.12 ±0.043	0.088±0.048	2.7 ± .15	.051± .023	1.1 ± .096
Hinkley:										
Bill Nelson Dairy	1/15	23	<3.2	<1.0	.70 ± .16	NA	NA	6.6 ± .24	.16 ± .040	5.1 ± .21
Lone Pine:										
Forest Service Ranger Station	1/16	24	<2.4	<.84	.32 ± .088	NA	NA	.36± .060	.019± .016	.27 ± .051
Olancha:										
Haiwee Reservoir	1/15	21	<3.5	<1.4	.32 ± .092	< .039	< .051	3.6 ± .17	.11 ± .030	3.1 ± .16
Ridgecrest:										
City Hall	1/15	23	<2.4	<.79	.29 ± .085	NA	NA	2.4 ± .14	.069± .026	2.0 ± .13
Nevada:										
Adaven:										
Canfield Ranch	1/16	22	<2.6	<1.1	.10 ± .059	NA	NA	2.9 ± .23	.040± .018	1.1 ± .11
Alamo:										
Williams Dairy	1/7	23	<2.4	< .90	.34 ± .094	NA	NA	3.7 ± .17	.098± .035	1.5 ± .12
Pahranagat Lake	1/7	21	<2.9	<1.1	.45 ± .10	< .038	< .068	23 ± .44	.31 ± .052	8.9 ± .28
Sheri's Bar	1/7	23	<3.0	<1.3	.18 ± .073	NA	NA	2.3 ± .14	.034± .018	.60 ± .072
Austin:										
Nevada National Bank	1/9	27	<5.5	<.77	.28 ± .086	NA	NA	16 ± .36	.54 ± .066	15 ± .35
Blue Diamond:										
Post Office	1/11	23	<1.3	<.78	.49 ± .11	NA	NA	1.5 ± .11	.022± .015	.43 ± .059
Blue Jay Highway Maintenance Station	1/17	23	<3.6	<1.1	.11 ± .060	NA	NA	3.1 ± .16	.055± .022	1.3 ± .10
Cactus Springs:										
Mobil Service Station	1/9	27	<2.2	<1.2	.12 ± .058	NA	NA	1.6 ± .12	.015± .013	.53 ± .068
Caliente:										
Agricultural Extension Station	1/10	23	<2.4	<.92	.11 ± .060	NA	NA	6.4 ± .23	.047± .022	1.5 ± .11
Clark Station:										
Five Mile Ranch	1/17	27	<2.4	<1.1	.12 ± .063	NA	NA	.70± .078	<.0089	.24 ± .046
Currant:										
Currant Ranch Cafe	1/16	27	<3.1	<.97	.089± .052	NA	NA	8.8 ± .61	.13 ± .036	3.1 ± .25
Diablo:										
Highway Maintenance Station	1/9	23	<3.7	<1.1	.11 ± .060	NA	NA	1.6 ± .12	.030± .026	.73 ± .085
Reed Ranch	1/7	21	<2.6	<1.0	.089± .057	<.031	<.064	22 ± .44	.14 ± .037	2.9 ± .16
Elgin:										
Water Tower	1/11	23	<3.0	<1.2	.10 ± .054	NA	NA	7.7 ±0.25	.094± .029	2.5± 0.14
Ely:										
Chevron Service Station	1/15	24	<2.2	<1.0	.63 ± .12	NA	NA	2.5 ± .22	.022± .018	.55 ± .080
Eureka:										
Highway Maintenance Station	1/15	24	<2.7	<.91	.13 ± .082	NA	NA	3.2 ± .26	.089± .035	1.1 ± .12
Goldfield:										
Chevron Service Station	1/8	23	<3.2	<1.1	.29 ± .086	NA	NA	2.2 ± .14	.036± .027	.56 ± .076
Hiko:										
Crystal Springs	1/10	27	<2.5	<.98	.67 ± .13	< .048	<.066	3.7 ± .18	.062± .038	1.2 ± .11
Schofield Dairy	1/7	23	<2.3	<.86	.29 ± .085	NA	NA	19 ±1.2	.26 ± .047	7.3 ± .49
Las Vegas:										
Desert Game Range	1/9	23	<1.7	<.99	.22 ± .075	NA	NA	6.4 ± .23	.082± .033	1.2 ± .10
Lab I NERC	1/14	24	<2.1	<.96	.094± .058	NA	NA	< .018	<.012	.021± .017
Lake Mead Vegas Wash	1/14	21	4.6±2.1	2.1 ±1.4	.23 ± .079	.046±0.046	<.085	2.9 ± .15	.070± .025	1.7 ± .12
Tule Springs	1/7	23	<1.6	<.96	[illegible] ± .059	NA	NA	2.8 ± .16	.039± .024	.76 ± .084
Tule Springs Pond	1/17	21	<3.0	<.99	[illegible] ± .092	<0.042	<.067	5.3 ± .21	.056± .037	1.6 ± .12
Craig Ranch Golf Course	1/14	23	<2[illegible]	1.3 ±1.1	[illegible] ± .092	NA	NA	1.8 ± .12	.021± .015	.65 ± .075
Las Vegas:										
Municipal Golf Course	1/14	23	<2.8	3.9 ±1.3	.13 ± .064	NA	NA	2.1 ± .13	.034±0.019	.60 ± .071
Vegas Estates	1/14	23	<2.4	6.5 ±1.6	.23 ± .071	NA	NA	2.9 ± .15	.048± .021	.71 ± .076
L V Water District Well 28	1/14	23	<2.0	<.91	.32 ± .085	NA	NA	1.8 ± .13	.042± .024	.52 ± .070
Lida:										
Lida Livestock Company	1/7	27	<2.5	<.97	.21 ± .077	NA	NA	2.0 ± .13	<.031	.48 ± .074
Pond at storage tank	1/7	21	<3.5	<1.3	.31 ±0.088	< .085	< .086	2.6 ± .15	.029± .016	.75 ± .080

See footnotes at end of table.

Table 2. Special analytical results for water samples collected during 1974—continued

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)							
			^{89}Sr	^{90}Sr	^{226}Ra	^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
Lund:										
Gardner Grocery	1/16	23	<2.7	<1.2	0.24 ±0.078	NA	NA	3.2 ±0.28	0.042±0.022	1.4 ±0.15
Manhattan:										
Country Store	1/10	23	<4.0	<1.2	.22 ± .072	NA	NA	11 ± .31	.16 ± .038	4.5 ± .19
Mesquite										
Hughes Bros. Dairy	1/15	23	<3.0	<1.0	.15 ± .060	NA	NA	3.7 ± .29	.067± .032	2.2 ± .19
Moapa:										
Pedersen Valley View Ranch	1/15	27	<3.2	<1.1	1.2 ± .16	NA	NA	4.4 ± .33	.060± [illegible]	1.3± .13
Mt. Charleston:										
Kyle Canyon Fire Station	1/7	27	<1.7	1.1 ±1.0	.30 ± .089	NA	NA	0.58± .072	.036± .020	.39 ± .057
Nyala:										
Sharp's Ranch	1/8	23	<4.2	<1.5	.14 ± .066	NA	NA	1.7 ± .12	.044± .020	.67 ± .076
Pahrump:										
Texaco Service Station	1/11	23	<1.4	<0.89	.19 ± .070	NA	NA	1.9 ±0.14	.042±0.022	0.48 ±0.068
Pioche:										
County Courthouse	1/10	24	<2.8	<1.1	.14 ± .066	NA	NA	2.0 ± .16	<.010	.50 ± .063
Round Mountain:										
Mobil Service Station	1/9	27	<3.0	<1.2	.14 ± .066	NA	NA	1.1 ± .10	.035± .020	1.1 ± .10
Scotty's Junction:										
Holloway Ranch	1/14	23	<3.0	<1.0	.11 ± .057	NA	NA	4.7 ± .35	.073±0.026	1.6 ±0.15
Springdale:										
Pond	1/8	21	<2.6	<1.1	.11 ± .060	<0.062	<0.083	6.3 ± .24	.082± .029	1.2 ± .11
Sunnyside:										
Wildlife Management Headquarters	1/16	27	<3.1	1.5± 1.3	.13 ± .056	NA	NA	2.2 ± .19	.016± .014	0.50 ± .071
Adam McGill Reservoir	1/16	21	<2.4	1.5 ±1.1	1.4 ± .20	<0.041	<0.083	2.6 ± .15	.022± .019	0.74 ± .082
Tonopah:										
Jerry's Chevron Station	1/8	23	<3.3	.96	.19 ± .067	NA	NA	3.5 ± .17	.060± .031	1.2 ± .10
Tonopah Test Range CP-1	1/8	23	<3.6	<1.1	.14 ± .067	NA	NA	.092± .047	<.023	0.054± .035
Warm Springs:										
Service Station and Cafe	1/17	27	<2.3	<.98	16 ± .60	NA	NA	.55± .073	<.012	0.15 ± .038
Twin Springs Ranch	1/10	23	<3.3	<1.0	.17 ± .064	NA	NA	5.0 ± .35	.11 ± .031	2.1 ± .17
Utah										
Cedar City:										
M. D. Baldwin Residence	1/16	24	<3.2	<1.1	.44 ± .11	NA	NA	.33± .058	<. 016	.14 ± .037
St. Georges:										
R. Cox Dairy	1/17	24	<3.0	<1.0	.13 ± 0.65	NA	NA	1.7 ±0.13	.039±0.022	.98 ± .094

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.
NS, no sample.

quested. A complete description of sampling and analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The routine analytical results of all water samples collected in the third quarter of 1974 by the NERC-LV are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the third quarter samples. Table 2 shows the results for water samples selected for special analyses during 1974.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
ERAMS krypton-85 in air component	January–June 1973	November 1974
ERAMS plutonium and uranium in air component	January–March 1974	November 1974
Fallout in the United States and other areas	1972	August 1974
Mexican air monitoring program	January–June 1974	November 1974

1. ERAMS Gross Radioactivity and Deposition Component, July 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage (figure 1). The component consists of 74 sampling stations, 54 of which are on standby status and can be activated when the need arises (figure 1). The remaining 20 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples, which are collected concurrently at the 20 air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A compilation

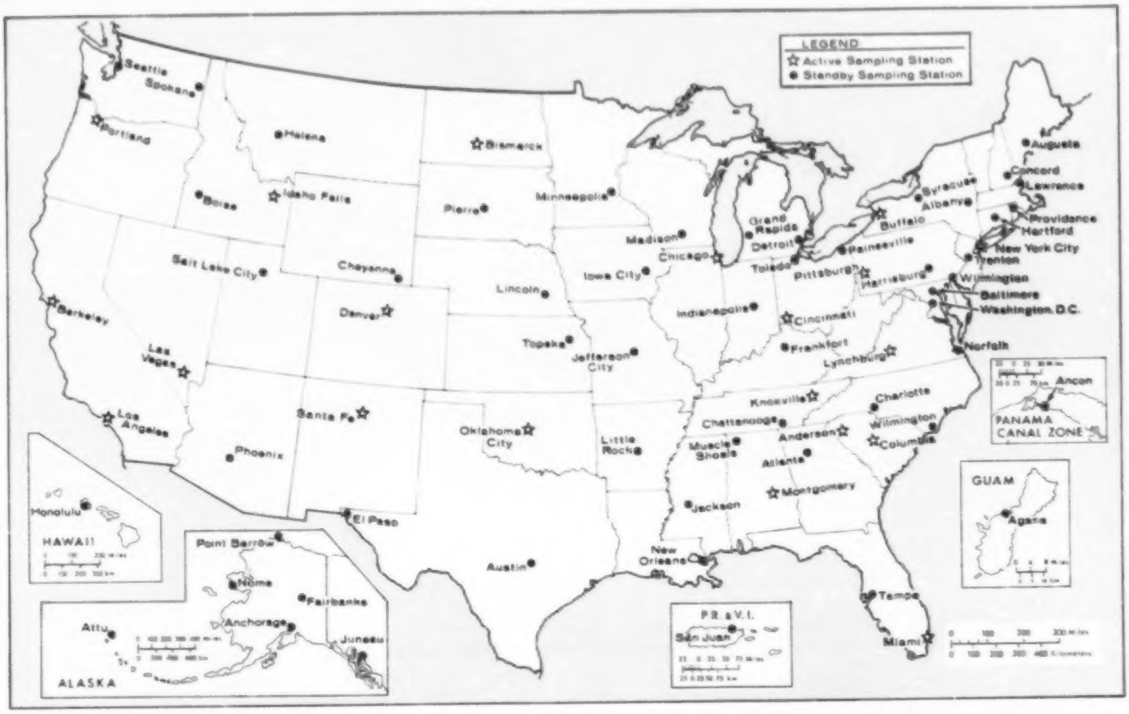
LEGEND
☆ Active Sampling Station
● Standby Sampling Station
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Idaho Falls
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Topeka
Las Vegas
Los Angeles
Phoenix
Santa Fe
Oklahoma City
El Paso
Austin
Madison
Chicago
Iowa City
Grand Rapids
Detroit
Toledo
Indianapolis
Jefferson City
Little Rock
Cincinnati
Frankfort
Knoxville
Chattanooga
Muscle Shoals
Anderson
Atlanta
Jackson
Montgomery
New Orleans
Tampa
Miami
Augusta
Concord
Lawrence
Syracuse
Albany
Buffalo
Providence
Hartford
Painesville
New York City
Trenton
Pittsburgh
Harrisburg
Wilmington
Baltimore
Washington, D.C.
Norfolk
Lynchburg
Charlotte
Wilmington
Columbia
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling locations

Table 1. Gross beta radioactivity in surface air and precipitation, July 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			3-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average [a]	Maximum	Minimum	Average [a]	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	3	1	2	0.19	0.06	0.11	54	0.34
	Muscle Shoals	0								
Alaska:	Anchorage	7	0	0	0	.15	.03	.08		
	Attu Island	5				<.01	<.01	<.01		
	Fairbanks	7				.09	.05	.06		
	Juneau	0								
	Nome	0								
	Point Barrow	0								
Ariz:	Phoenix	0								
Ark:	Little Rock	4	1	0	1	.22	.08	.16		
Calif:	Berkeley	10	0	0	0	.30	.02	.07	9	.04
	Los Angeles	14	2	0	1	.14	.03	.09		
C.Z:	Ancon	3	0	0	0	.09	.01	.04		
Colo:	Denver	13	4	1	2	.32	.05	.17	38	.78
Conn:	Hartford	5	1	0	1	.21	.07	.13	40	1.79
	Wilmington	4	1	0	1	.26	.08	.19		
D.C:	Washington	5	0	0	0	.31	.07	.21		
Fla:	Jacksonville [b]	23	1	0	0	.28	.03	.12		
	Miami	21	3	0	0	.14	.03	.07	104	1.27
Ga:	Atlanta	6				.29	.08	.18		
Guam:	Agana	0								
Hawaii:	Honolulu	4	0	0	0	.12	.08	.09		
Idaho:	Boise	4	1	1	1	.19	.13	.16		
	Idaho Falls	8				.27	.08	.16		
Ill:	Chicago	3	2	0	1	.20	.17	.18		
Ind:	Indianapolis	5	0	0	0	.26	.11	.17		
Iowa:	Iowa City	5	3	1	2	.24	.14	.18		
Kans:	Topeka	3	3	1	2	.22	.07	.15		
Ky:	Frankfort	2	1	1	1	.20	.13	.17		
La:	New Orleans	3	0	0	0	.20	.10	.15		
Maine:	Augusta	22	1	0	0	.17	.02	.11	52	1.63
Md:	Baltimore	3	1	0	1	.28	.09	.20	10	.43
Mass:	Lawrence	0								
Mich:	Grand Rapids	0								
	Lansing [c]	22	3	0	1	.22	.04	.13	30	1.52
Minn:	Minneapolis	7	3	1	2	.31	.10	.22		
Miss:	Jackson	10	1	0	1	.21	.09	.14		
Mo:	Jefferson City	5	2	1	1	.24	.12	.18	17	.92
Mont:	Helena	5	2	1	1	.19	.10	.15		
Nebr:	Lincoln	4	4	1	3	.17	.12	.14		
Nev:	Las Vegas	12	3	1	1	.28	.05	.14	8	.04
N.H:	Concord	0								
N.J:	Trenton	22	2	0	1	.30	.07	.17	81	5.7
N. Mex:	Santa Fe	7	2	0	1	.55	.05	.15		
N.Y:	Albany	4	1	0	1	.17	.09	.14		
	Buffalo	9	1	0	1	.23	.12	.17	6	.01
	New York City	0								
	Syracuse	3				.18	.16	.17		
N.C:	Charlotte	0								
	Wilmington	0								
N. Dak:	Bismarck	10	5	0	1	.23	.09	.13	40	.76
Ohio:	Cincinnati	0								
	Columbus [d]	15	4	1	2	.59	.10	.21		
	Painesville	0								
Okla:	Oklahoma City	0								
Oreg:	Portland	9	0	0	0	.10	.03	.06	41	.22
Pa:	Harrisburg	21	2	0	1	.27	.08	.14	7	.33
	Pittsburgh	0								
P.R:	San Juan	4				.11	.07	.09		
R.I:	Providence	13	1	0	1	.23	.08	.13		
S.C:	Anderson	0								
	Columbia	14	2	0	1	.23	.05	.12	150	1.68
S. Dak:	Pierre	9				.23	.11	.17		
Tenn:	Chattanooga	0								
	Nashville [e]	15	3	1	1	.34	.09	.18	22	.34
Tex:	Austin	4	3	2	2	.24	.07	.10		
	El Paso	7	3	0	1	.14	.04	.09		
Utah:	Salt Lake City	0								
Va:	Lynchburg	11	2	0	1	.30	.04	.12		
	Norfolk	4	1	0	0	.24	.02	.14		
Wash:	Seattle	6	0	0	0	.06	.02	.05		
	Spokane	8	2	1	1	.12	.04	.09		
Wisc:	Madison	8	2	0	1	.24	.09	.15	11	.46
Wyo:	Cheyenne	5	6	2	3	.25	.14	.21		
Network summary		480	6	0	1	0.59	<0.01	0.14	40	1.01

[a] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
[b] Station to be relocated in Tampa.
[c] Station to be relocated in Detroit.
[d] Station to be relocated in Toledo.
[e] Station to be relocated in Knoxville.

of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during July 1974. The standby stations were activated following the June 17, 1974, detonation of an atmospheric nuclear test by the Peoples Republic of China, and were operational through most of July 1974.

2. Air Surveillance Network, July 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All standby stations except six stations near the NTS, were activated from June 19 to mid-July for the purpose of checking the operability of the stations and collecting radioactive fallout from a nuclear detonation conducted by the People's Republic of China on June 16, 1974. All samples were mailed to the NERC-LV. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m^3. For reporting purposes, concentrations less than 1.0 pCi/m^3 are reported to one significant figure, and those equal to or greater than 1.0 pCi/m^3 are reported to two significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration (MDC) (~0.03 pCi/m^3 for a 700 m^3 sample) are set equal to the MDC. Reporting and rounding-off conventions are as follows:

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[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

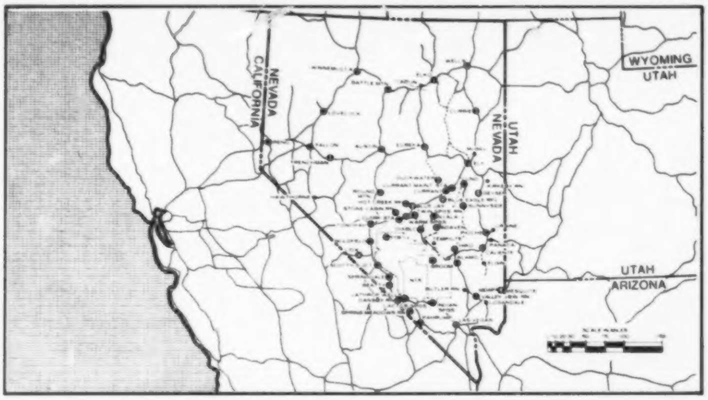

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	<0.1	<0.1
≥ 0.05 <0.15	0.1	<0.1
≥ 0.15	As calculated and rounded	Calculated MDC

Table 2. Summary of gross beta radioactivity concentrations in air, July 1974

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average
Ariz:	Kingman	14	.8	<.1	.3
	Phoenix	6	.3	.2	.2
	Seligman	14	.9	.1	.3
	Winslow	5	.7	.2	.4
Ark:	Little Rock	4	.2	.1	.2
Calif:	Baker	27	.6	<.1	.3
	Barstow	23	.7	<.1	.2
	Bishop	14	.9	.1	.4
	Death Valley Junction	14	.7	.1	.3
	Furnace Creek	14	.7	<.1	.3
	Indio	5	.5	.1	.3
	Lone Pine	14	.6	.1	.3
	Needles	4	.5	.2	.4
	Ridgecrest	14	.4	.1	.2
	Shoshone	14	.4	.1	.2
Colo:	Denver	5	1.0	.4	.6
	Durango	1	.2	.2	.2
Idaho:	Boise	6	.3	.2	.2
	Idaho Falls	6	.5	.3	.4
	Preston	2	.5	.4	.4
	Twin Falls	5	.3	.2	.3
Iowa:	Iowa City	5	.3	<.1	.2
	Sioux City	6	.5	.1	.3
Kans:	Dodge City	3	.2	.1	.2
La:	Lake Charles	5	.2	.1	.1
	Monroe	5	.3	<.1	.1
	New Orleans	2	.3	.1	.2
Mo:	Clayton	5	.4	.2	.2
	Joplin	5	.5	.1	.2
	St. Joseph	5	.4	.2	.2
Nebr:	North Platte	5	.6	<.1	.2
Nev:	Alamo	13	.7	.1	.3
	Austin	13	.5	.1	.2
	Battle Mountain	5	.5	.1	.3
	Beatty	14	.8	<.1	.2
	Blue Eagle Ranch (Currant)	14	.4	<.1	.2
	Blue Jay	14	.5	<.1	.2
	Caliente	13	.5	<.1	.2
	Currant Ranch	12	.6	.1	.3
	Currie	3	.3	.2	.2
	Diablo	14	.7	.1	.3
	Duckwater	12	.7	<.1	.3
	Elko	5	.6	.2	.4
	Ely	13	.6	<.1	.2
	Eureka	14	.6	.1	.3
	Fallini's Twin Springs Ranch	14	.6	<.1	.3
	Fallon	4	.5	.1	.4
	Frenchman Station	4	.5	.2	.4
	Geyser Ranch (Pioche)	6	.7	<.1	.2
	Goldfield	14	.6	<.1	.2
	Groom Lake	10	.4	.1	.2
	Hiko	14	.7	.1	.3
	Indian Springs	14	.5	.1	.2
	Las Vegas	21	.7	.1	.3
	Lathrop Wells	15	.4	.1	.2
	Lida	11	.2	<.1	.1
	Lund	14	.7	<.1	.2
	Mesquite	14	.5	.1	.2
	Nyala	14	.8	<.1	.3
	Pahrump	14	.9	.1	.3
	Pioche	14	.5	.1	.2
	Reno	5	.4	.1	.3
	Round Mountain	14	.8	.1	.3
	Scotty's Junction	13	.6	.1	.8
	Stone Cabin Ranch	14	.2	<.1	.1
	Sunnyside	12	.6	.1	.2
	Tonopah	14	1.4	.1	.4
	Tonopah Test Range	14	.7	.1	.2

Table 2. Summary of gross beta radioactivity concentrations in air, July 1974—continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average
Nev:	Warm Springs	6	0.4	<0.1	0.2
	Warm Springs Ranch	8	.1	<.1	.1
	Wells	5	.6	.3	.4
	Winnemucca	5	.5	.2	.3
N. Mex:	Albuquerque	5	.8	<.1	.3
	Carlsbad	5	.3	.1	.1
Okla:	Muskogee	5	.3	.1	.2
Oreg:	Burns	5	.4	.2	.3
	Medford	2	.2	.1	.2
S. Dak:	Aberdeen	4	.4	.1	.2
	Rapid City	5	.4	.2	.3
Tex:	Abilene	5	.2	.1	.1
	Austin	9	.2	.1	.1
	Fort Worth	5	.2	.1	.1
Utah:	Bryce Canyon	10	.7	.2	.4
	Cedar City	5	.2	.1	.1
	Delta	14	.4	<.1	.2
	Dugway	5	.7	.2	.5
	Enterprise	5	.6	.3	.4
	Garrison	14	.6	.1	.3
	Logan	4	.5	.3	.4
	Milford	13	.7	<.1	.2
	Monticello	5	.3	<.1	.2
	Parowan	5	.8	.2	.4
	Provo	4	.6	.2	.4
	Salt Lake City	5	.4	.2	.4
	St. George	13	.4	.1	.2
	Wendover	4	.7	.3	.4
Wash:	Seattle	5	.1	<.1	.1
	Spokane	5	.2	<.1	.1
Wyo:	Rock Spring	4	.8	.2	.5
	Worland	5	.5	.4	.4

As shown by table 2, the highest gross beta concentrations within the network was 1.4 pCi/m^3 at Tonopah, Nev., during July 19–22 1974.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-106, and cerium-144 were identified on filters collected throughout the network. Trace amounts of uranium-237 were also

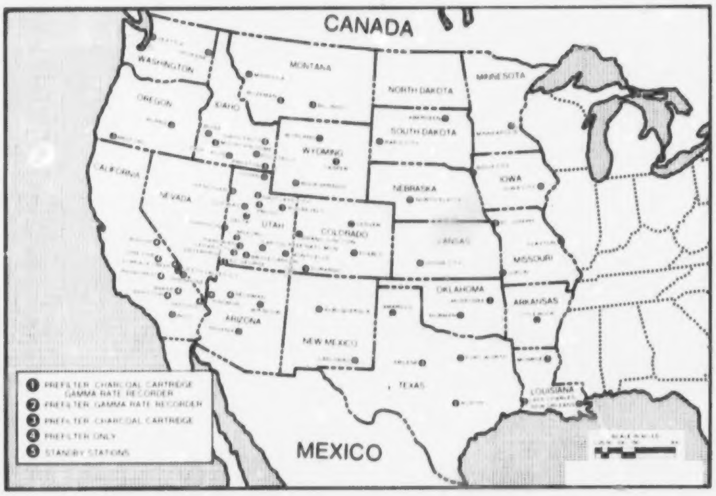
CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
CALIFORNIA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
❶ PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
❷ PREFILTER GAMMA RATE RECORDER
❸ PREFILTER CHARCOAL CARTRIDGE
❹ PREFILTER ONLY
❺ STANDBY STATIONS

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

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detected, but were insufficient for quantitation. The highest concentrations of these radionuclides, respectively, were as follows:

Radionuclide	Maximum concentration (pCi/m³)	Station	Collection period
Zirconium-95	0.93	Fallini's Ranch, Nev.	June 28-July 1
Ruthenium-106	.95	Pahrump, Nev.	July 5-8
Cerium-144	.44	Las Vegas, Nev.	July 2-3
Barium-140	.47	Fallini's Ranch, Nev.	July 5-8

These radionuclides are attributed to seasonal variations in worldwide fallout and a nuclear detonation by the People's Republic of China. No radionuclides were identified by gamma spectrometry on any charcoal cartridges during July 1974.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

3. Canadian Air and Precipitation Monitoring Program,[3] July 1974

Radiation Protection Bureau
Department of National Health
and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

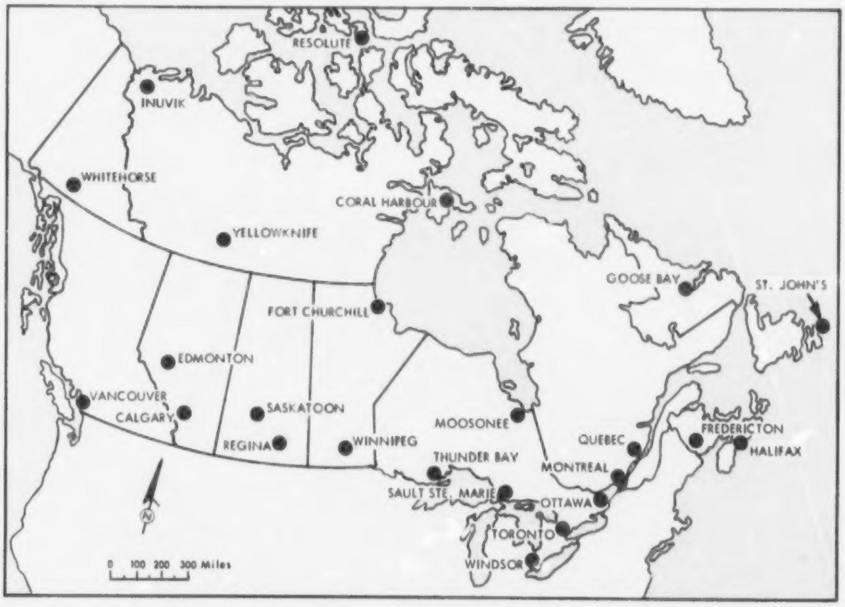
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 4. Canadian air and precipitation sampling stations

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[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, July 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	20	0.33	0.05	0.19	89.0	3.4
Coral Harbour	23	.17	.01	.09	NS	NS
Edmonton	20	.21	.02	.12	47.1	6.1
Ft. Churchill	20	.18	< .01	.09	86.6	2.5
Fredericton	17	.22	.02	.12	82.8	4.4
Goose Bay	20	.20	< .01	.10	57.1	3.5
Halifax	21	.28	.02	.15	51.5	5.0
Inuvik	19	.23	.01	.12	43.4	3.6
Montreal	20	.32	.02	.17	51.0	7.4
Moosonee	20	.24	.01	.13	38.3	5.3
Ottawa	11	.18	.01	.10	50.1	3.9
Quebec	22	.46	< .01	.23	11.1	2.1
Regina	18	.50	.04	.27	89.6	3.5
Resolute	5	.24	.02	.13	87.2	3.1
St. John's, Nfld	17	.29	.01	.15	23.2	2.1
Saskatoon	20	.23	< .01	.12	91.2	5.3
Sault Ste. Marie	20	.26	.01	.14	79.1	2.6
Thunder Bay	31	.46	.04	.25	74.9	3.5
Toronto	NS				129.8	3.1
Vancouver	18	.63	.01	.32	79.6	6.0
Whitehorse	20	.25	.01	.13	66.3	3.3
Windsor	NS				49.9	3.6
Winnipeg	20	4.76	< .01	2.38	77.4	2.5
Yellowknife	12	.22	.03	.03	60.8	2.8
Network summary	414	4.76	<0.01	0.25	66.0	3.9

NS, no sample.

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for July 1974 are presented in table 3.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

4. Pan American Air Sampling Program July 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The July 1974 air monitoring results from the participating countries are given in table 4.

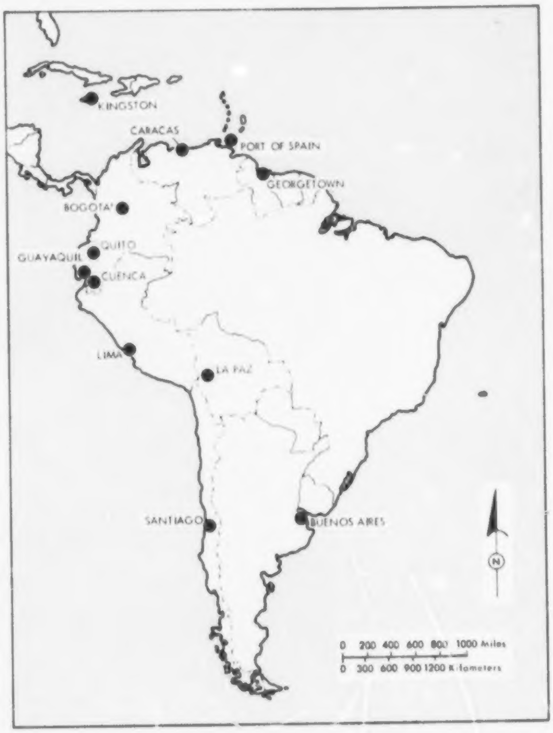

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, July 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	30	4.06	0.00	0.53
Colombia:	Bogota	23	.43	.00	.09
Ecuador:	Cuenca	18	12.42	.01	2.15
	Guayaquil	30	2.95	.01	.53
	Quito	8	9.78	.00	1.33
Guyana:	Georgetown	1	.01	.01	.01
Jamaica:	Kingston	0			
Peru:	Lima	5	.19	.06	.13
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	2	.06	.03	.05
Pan American sum.		117	12.42	0.00	0.72

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program July 1974

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

One of the objectives of the program is to evaluate the possibility that fixed effluent

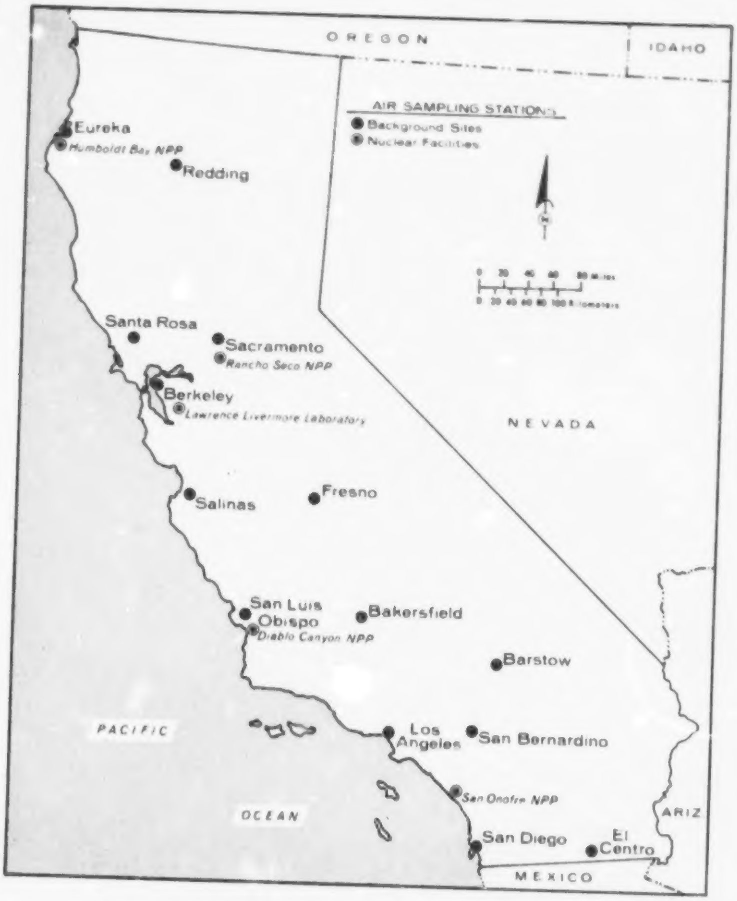
OREGON
IDAHO
AIR SAMPLING STATIONS
● Background Sites
● Nuclear Facilities
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Humboldt Bay NPP
Redding
Santa Rosa
Sacramento
Rancho Seco NPP
Berkeley
Lawrence Livermore Laboratory
NEVADA
Salinas
Fresno
San Luis Obispo
Diablo Canyon NPP
Bakersfield
Barstow
PACIFIC
OCEAN
Los Angeles
San Bernardino
San Onofre NPP
San Diego
El Centro
ARIZ
MEXICO

Figure 6. California air sampling program stations

sources contribute to particulate activity in the air. Consequently, data from continuous air samplers placed in proximity to nuclear facilities are compared with those from similar equipment in nearby communities and at several "background" stations.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2-cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health. The filters are analyzed for gross alpha and beta radioactivity, 72-hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the gross beta radioactivity in air for July 1974.

Table 5. Gross beta radioactivity in California air, July 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	22	0.61	0.15	0.35
Barstow	28	.85	.10	.34
Berkeley	31	.45	.00	.11
Diablo Canyon Nuclear Power Plant	8	.15	.05	.11
El Centro	21	1.93	.05	.30
Eureka	21	.36	.01	.12
Fresno	16	.50	.18	.29
Humboldt Bay Nuclear Power Plant	14	.20	.00	.09
Livermore	21	.32	.00	.18
Los Angeles	21	.41	.08	.18
Rancho Seco Nuclear Power Plant	14	.44	.09	.26
Redding	12	1.06	.19	.59
Sacramento	22	.30	.06	.17
Salinas	22	.48	.04	.13
San Bernardino	20	.44	.08	.26
San Diego	23	.28	.09	.12
San Luis Obispo	22	.26	.05	.14
San Onofre Nuclear Generating Station	4	.23	.12	.17
Summary	342	1.93	0.00	0.22

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site, July-December 1970[1]

National Environmental Research Center—
Las Vegas[2] and
Nevada Operations Office, AEC

In accordance with a Memorandum of Understanding between the U.S. Atomic Energy Commission (AEC) and Environmental Protection Agency (EPA), the National Environmental Research Center, Las Vegas (NERC-LV) conducted a program of radiological monitoring and environmental sampling in the offsite area surrounding the Nevada Test Site (NTS) and the Project Rulison test well.

During the period, July through December 1970, six announced underground nuclear tests were sponsored by the U.S. Atomic Energy Commission at the NTS and natural gas production test flaring operations were conducted at the Project Rulison site. The results of surveillance performed for "Baneberry" and Project Rulison are summarized in this report.

For the NTS, the offsite area is defined as that area beyond the boundary of the NTS and adjacent restricted areas such as the Nellis Air Force Range, Tonopah Test Range, and the Nuclear Rocket Development Station. For simplicity, these combined areas will be referred to in this report as the test range complex. At Project Rulison near Grand Junction, Colo., the offsite area extended from a 180-meter radius from the experimental natural gas well.

Operational procedures

Before each event at the test range complex, mobile monitoring teams were sent to the offsite areas most likely to be affected by a release of radioactive material. When a release occurred, the teams conducted a monitoring program directed from the NTS Control Point via two-way radio communications. Environmental sampling and monitoring continued until levels of radioactivity returned to background levels.

Each monitor carried two Eberline E-500B GM survey meters, one Rank Nucleonics NE-148 scintillation instrument, and one Victoreen Radector, Model No. AGB-50B-SR, ionization chamber instrument for monitoring radiation levels. The E-500B has a range of 0 to 200 milliroentgens per hour (mR/h) for gamma or beta-gamma detection in four ranges with an external halogen-quenched Geiger-Mueller (GM) tube, and a 0 to 2000 mR/h range for gamma detection from an internal Anton 302 GM tube. The NE-148, which has a 2.5 by 4 cm sodium iodide crystal detector, is used primarily to indicate the presence of low levels of gamma radiation and has a range of 0 to 3 mR/h in three ranges. The Radector has a range of 0.05 to 50 000 mR/h over two logarithmic ranges, using an inert gas ionization chamber as the detector. These instruments were routinely calibrated to ± 20 percent with a standardized cesium-137 source. Each monitor was also equipped with portable battery-operated strip chart recorders, battery-operated air samplers, and equipment for collecting milk, water, and vegetation samples. Extra thermoluminescent dosimeters were issued to residents in the downward trajectory in the event of a release of radioactivity.

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[1] This article is a summary of report No. NERC-LV-539-17, "Off-site Surveillance Activities of the National Environmental Research Center from July through December 1970."

[2] During the period of this report, the NERC-LV was the Southwestern Radiological Health Laboratory and the Western Environmental Research Laboratory.

For Project Rulison, monitors also carried portable battery-operated samplers equipped with molecular sieve sampling heads and battery-powered compressors for tritium and noble gas sampling. The monitors were positioned according to aerial plume-tracking information which was radioed directly from the aircraft.

Exposure rate recorders

Eberline RM–11 gamma exposure rate recorders were used to document cloud passage at fixed locations (figure 1). These recorders have a GM tube detector with a 0.01 to 100 mR/h range and are calibrated to ± 20 percent with a cesium-137 source. The gamma exposure rate is recorded on a 30-hour strip chart.

Aerial cloud tracking

For each event at the test range complex, an Air Force U-3B aircraft with two NERC-LV monitors carrying portable instruments similar to those used by ground monitors was used to track any radioactive effluents. A NERC-LV T–34 aircraft was also used for tracking for Baneberry. Two NERC-LV cloud sampling and tracking aircraft were also used to obtain in-cloud samples to assess total cloud volume, to provide long-range tracking, and to assist in positioning ground monitors.

For project Rulison gas flaring operations, aerial plume-tracking and sampling were performed with a twin-engine Turbo-Beech aircraft. Since radioactivity concentrations in the plume from the gas-flaring stack were so low that gamma and beta detectors could not be used, plume-tracking was accomplished with a condensation nuclei monitoring instrument. This instrument, which measured the airborne concentration of condensation nuclei resulting from the burning of the natural gas, was mounted in the aircraft cabin immediately behind an air baffle at the discharge end of an air sampling probe mounted in the nose of the aircraft. The instrument output was fed to a strip-chart recorded in the copilot's instrument panel, providing the crew chief with continuous information on plume trajectory, size and dispersion. This information was radioed to a ground control center so that ground monitoring personnel would be positioned to collect samples in the plume ground track.

Atmospheric moisture and noble gas samples in the plume were collected from the aircraft sampling probes with a grab sampler. Grab

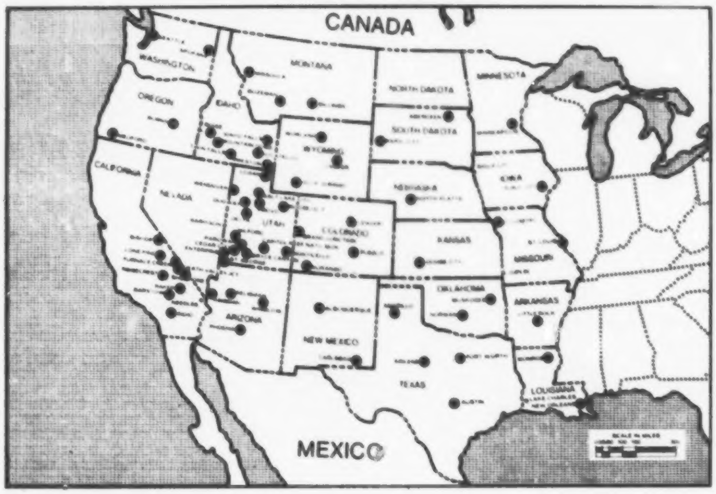

Figure 1. NERC-LV Air Surveillance Network stations outside Nevada

samples were obtained by gathering air from the sampling probe in a 1-cubic-meter plastic bag over a 30-second period. The collected air was then pumped through a canister containing 1000 grams of Linde type 13X molecular sieve for water vapor and CO_2 collection, and then into a compressed air bottle. Cryogenic sampling was used to freeze out H_2O, CO_2, and noble gases. The molecular sieve material and air bottles were then returned to the NERC-LV for tritium and noble gas analysis.

Air sampling

During this 6-month period, the routine NERC-LV Air Surveillance Network consisted of 102 offsite stations operating in every State west of the Mississippi River, except Montana and North Dakota (figures 1–2). In addition, 10 standby stations were available to be activated by telephone. The air sampler used in the Air Surveillance Network is a Gelman Tempest, consisting of a Gast Model 1550 vacuum pump driven by an electric motor. The sampler has an approximate flow rate of 0.3 m^3/min and uses a 10 cm diameter glass-fiber filter. Activated charcoal cartridges were placed behind the filter at 22 offsite stations near the test range complex and could be added to the other stations when necessary to collect gaseous fission products. The total volume of air sampled was calculated from the average flow rate and the total sampling time. These samplers operate 24 hours a day. During this period, eight additional standby stations were established in Nevada. These stations were set up to be operated by NERC-LV personnel if a release of radioactivity occurred.

Continuous collection of atmospheric particulate and moisture samples during Project Rulison flarings was accomplished at seven fixed monitoring stations at populated locations in the vicinity of the test well. Metal storage sheds were set up to house the samplers. Air was drawn through a particulate filter located outside the shed and then through a canister containing 700 grams of molecular sieve for water collection. The samplers were operated for 48-hour periods at an average flow rate of 3 liters/min.

Additionally, portable battery-powered air samplers were used to collect atmospheric moisture samples at ground level. Based on aerial tracking information, monitoring personnel were positioned in the downwind plume trajectories. The monitors carried portable two-way radios to receive instructions concerning sampling times and position changes. The portable sampler consisted of an automobile-type vacuum cleaner powered by a 12-volt battery. Air flow was measured by a dry gas meter. Air was first passed through a 10-cm-diameter glass fiber filter to remove particulates, and then passed through a 300-gram molecular sieve canister to remove the moisture. A battery-

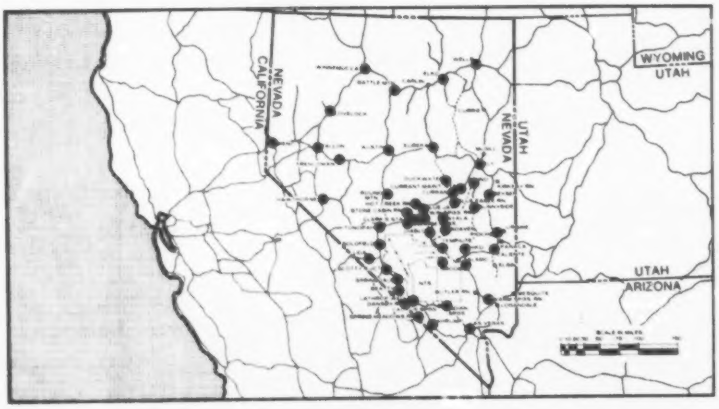

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

powered compressor was also used to collect air samples for tritium and noble gas analysis. Carbon-14 analysis was performed on the CO_2 obtained from molecular sieve samples.

Milk and water sampling

Routine sampling of milk from commercial dairies, producer dairies and family cows around the test range complex continued through the 6-month period (figure 3). About 30 sources were routinely sampled, most on a monthly basis. A total of 190 samples was collected from these locations. In the event of cloud passage over a specific area, intensified sampling within the area was conducted to document changes in activity.

A standby network which could be activated by telephone and consisting of 185 milk processing plants located in the 11 western States was maintained. Each plant was supplied with containers and mailing cartons to send daily samples for 1 week to the NERC-LV for analysis. Periodically, sections of the network were

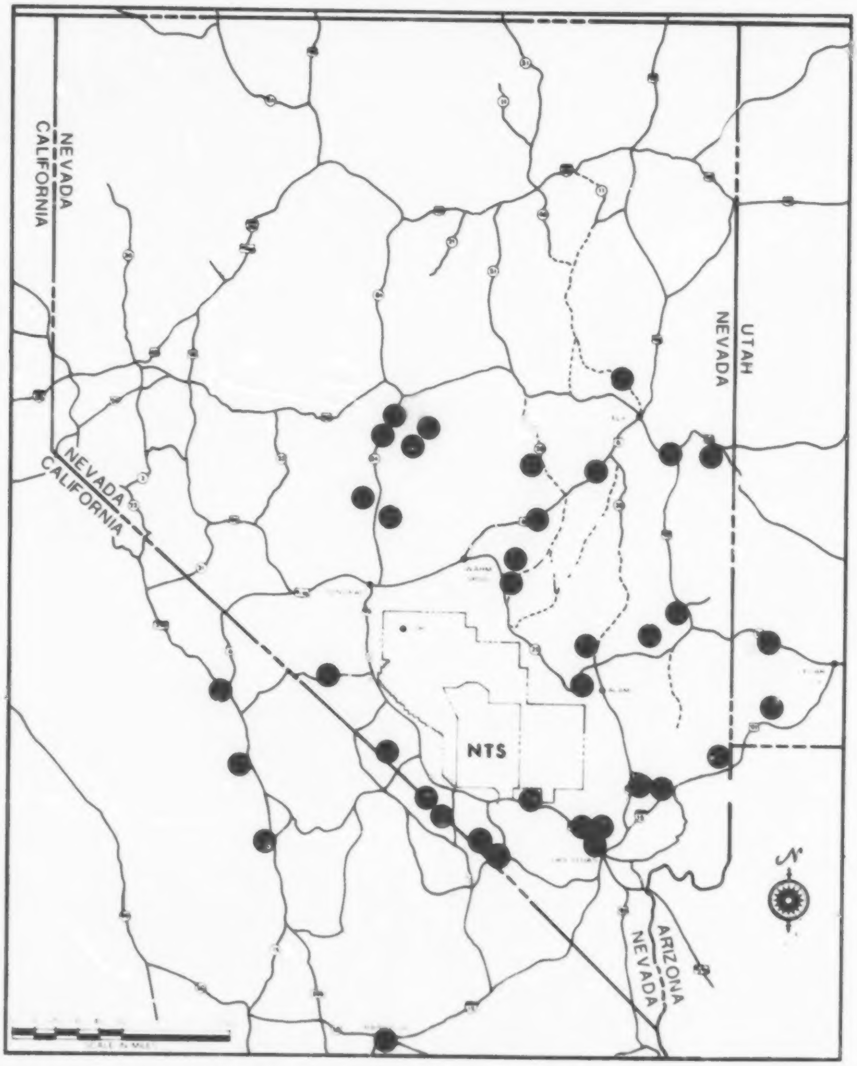

Figure 3. Routine milk sampling stations

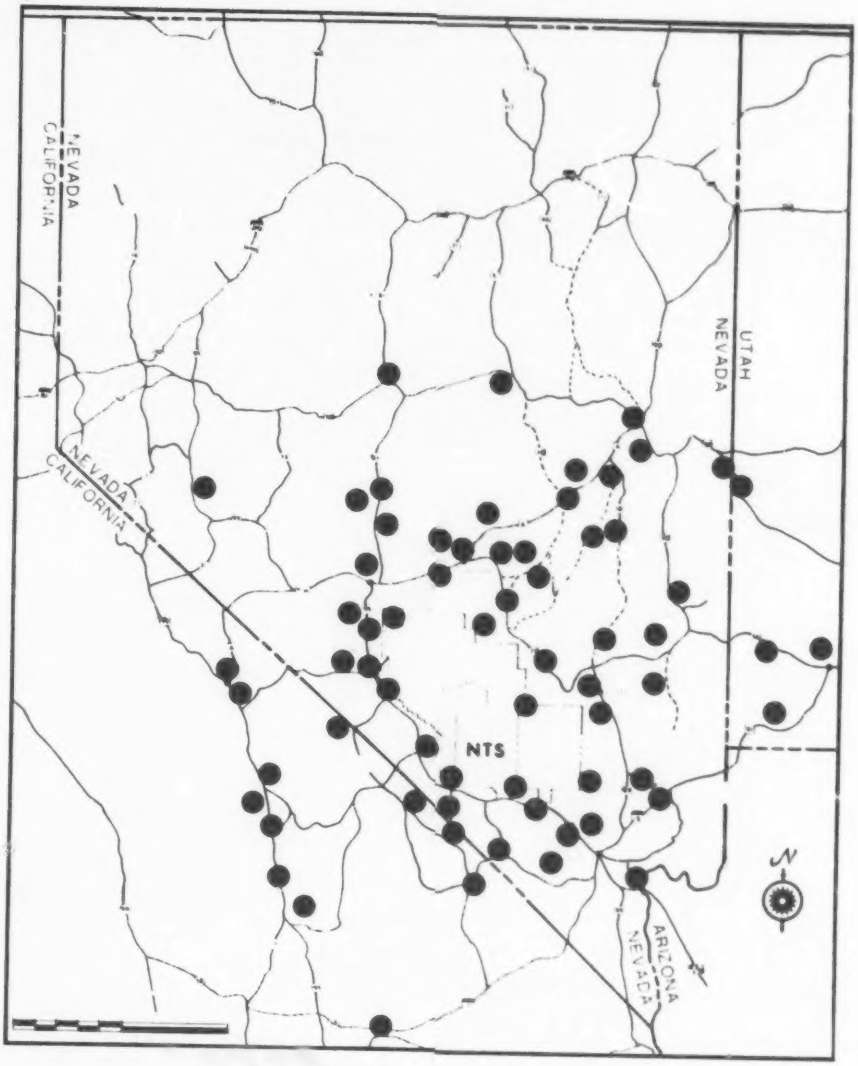

Figure 4. Routine water sampling stations

activated to test the response and reliability of the system. During this reporting period, 300 samples were collected from the network.

Domestic and nondomestic water supplies around the test range complex were sampled on a routine basis (figures 4 and 5). Water sampling was increased when a release occurred. During this period, 569 water samples were collected from about 90 sources.

A total of 62 milk and 251 water samples was collected from special sampling locations in the Rulison vicinity. Daily water samples were collected from Battlement Creek, which runs within several hundred meters of the test well, while all other water sampling stations were sampled on a monthly schedule. The sampling stations included both domestic and surface water supplies. Milk samples from family cows

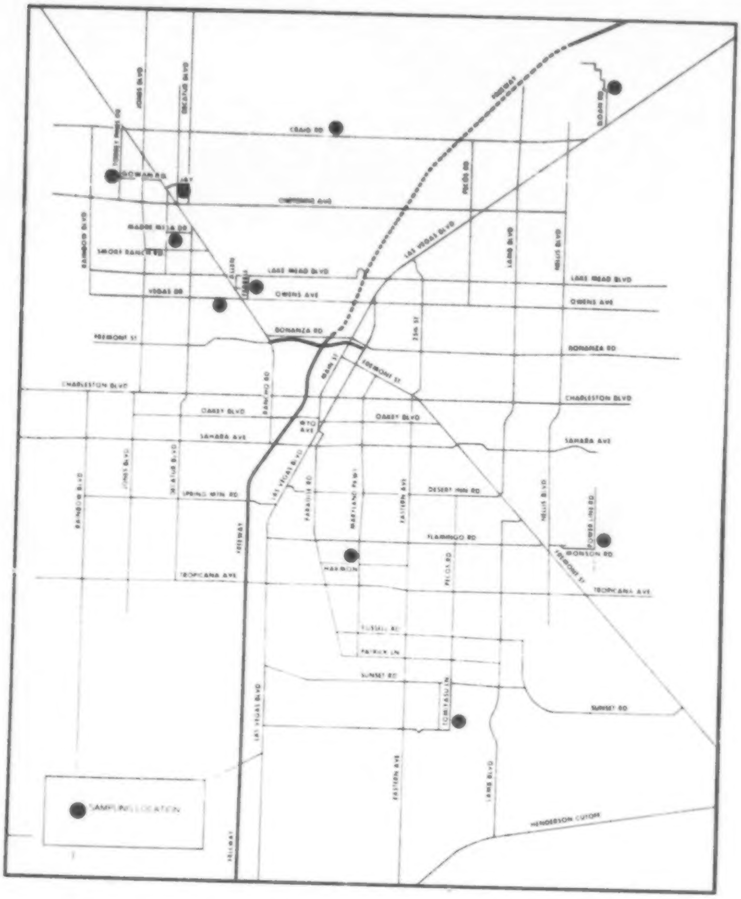
CRAIG RD
CHEYENNE AVE
LAKE MEAD BLVD
OWENS AVE
BONANZA RD
FREMONT ST
CHARLESTON BLVD
OAKEY BLVD
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
LAS VEGAS BLVD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
PECOS RD
LAMB BLVD
NELLIS BLVD
HARMON
BOULDER HWY
HENDERSON CUTOFF
FREEWAY
SAMPLING LOCATION

Figure 5. Las Vegas Valley routine water sampling stations

and Grade-A dairies were also collected on a monthly basis for tritium analysis.

Precipitation collectors were provided at seven fixed sampling stations, and portable precipitation collectors were set up by field personnel at other locations as conditions dictated. Snow samples were collected during the winter flaring operations.

Vegetation sampling

Normally, vegetation samples around the test range complex were collected only in the event of a release of radioactive material and analyzed for gross gamma radioactivity to delineate the fallout pattern. At most locations where milk samples were collected, samples of cow feed were collected and analyzed for specific radionuclides. For Project Rulison, 95 natural vegetation samples were collected within a 32-km radius of the site. All samples were analyzed for tritium.

Special sampling for Project Rulison

Periodic samples of animal tissue from both wildlife and domestic animals were collected through the assistance of local slaughter houses and the Colorado Fish, Game and Parks Department. Several blood samples were also collected from domestic livestock for tritium analysis when tissue was not available from a particular area of interest or at a particular time of interest (for example: livestock near the mouth of the Battlement Creek Valley immediately following a flaring operation). One hundred thirteen urine samples were collected from 20 residents in the area and analyzed for tritium.

Food crop sampling for Project Rulison

Samples of food crops were collected prior to the release of any gas to document background levels of tritium in these crops. These backgrounds ranged from 420 pCi/liter to 3100 pCi/liter of water with an average of 1300 pCi/liter. Following flaring, 24 samples of food crops, 7 samples of garden crops and 15 samples of orchard crops were collected and analyzed. There were no tritium concentrations above background levels. Detailed data are reported elsewhere (*1*).

Soil sampling for Project Rulison

Soil samples were collected prior to any release of gas to document background levels of tritium. For surface soil samples, these background levels ranged from less than 400 pCi/liter to 1400 pCi/liter of water with an average above the minimum detectable amount (MDA) of 1000 pCi/liter of water. For soil samples collected from a depth of 15 cm, the background ranged from less than 400 pCi/liter to 1100 pCi/liter of water with an average above the MDA of 750 pCi/liter of water. A total of 102 soil samples was collected during this 6-month period. Detailed data are reported elsewhere (*1*).

Dosimetry

Ninety-four dosimetry stations (figure 6)

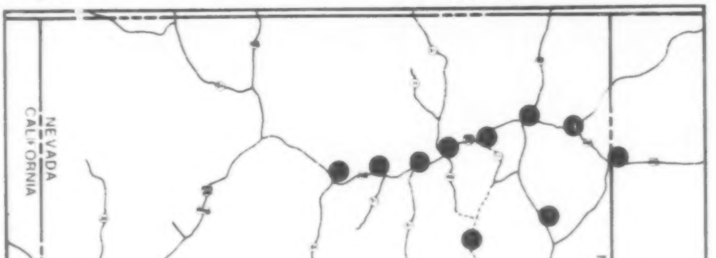

Figure 6. Routine dosimetry stations

located around the test range complex were equipped with three EG&G Model TL–12 thermoluminescent dosimeters (TLD) each, and about 60 offsite residents wore one TLD each. These TLD's were exchanged monthly. The TLD's have a uniform energy response from 50 keV to 1.25 MeV with a low energy cutoff at 50 keV. According to past TLD data, a reading at 5 mR above the previous month's background constitutes a detectable exposure. For the period of July to October 26, 24 TLD stations were located around the Project Rulison site. During this period, early snows made some stations inaccessible and the number of stations was reduced to 17. Due to low exposure rates, the network was further reduced to four close-in stations on December 1.

Community relations

Frequent contacts with the offsite population by NERC-LV field personnel and presentations for schools and civic groups provided the opportunity to explain the surveillance role of the EPA and the AEC testing programs. A number of offsite residents took part in the environmental sampling program. All routine air sampling stations except the one at Las Vegas were operated by local citizens.

Medical and veterinary services

A NERC-LV medical officer was available in the event complaints of a medical nature arose as a result of the nuclear testing program. He also provided liaison with local physicians. Veterinary officers of the NERC-LV Radiological Research Program provided a complete veterinary response capability. These officers, familiar with the livestock and dairy industries, wildlife, prevalent diseases, and poisonous plants in the area around NTS, maintained liaison with State and federal regulatory officials, local practioners, county agents, fish and wildlife officials, and other agricultural leaders. The program has two specially-equipped trucks capable of supporting field diagnoses and post mortems.

Analytical procedures

Analytical procedures are described in NVO 28 (*2*).

Results

A summary of monitoring results obtained for those operations resulting in a release of radioactivity to the offsite areas is presented here. Detailed data are reported separately (*1–3*). Routine surveillance network reports are available from the NERC-LV.

Project Rulison

The Project Rulison flaring operations during this 6-month period were conducted on the dates summarized in table 1.

Table 1. Summary of Project Rulison flaring operations

Flaring period	Start date (1970)	End date (1970)	Volume gas flared (Mm^3 standard)
Preliminary flow tests[a]	8/1	8/22	0.03
Calibrated tests[b]	10/4	10/07	.34
High rate	10/27	11/03	3.1
Intermediate rate	12/1	12/20	2.8

[a] Nine short runs up to 8 hours duration.
[b] Three short runs up to 14 hours duration.

Table 2 shows the total number of samples collected during this report period. Tritium and krypton-85 were the primary radionuclides released by the flaring operations. All environmental samples, except for the particulate air filters and charcoal cartridges, were analyzed for tritium. The natural gas samples, cryogenic samples, and compressed air samples were also analyzed for krypton-85.

Table 2. Project Rulison offsite environmental sampling[a]

Sample type	Total number of samples
Air (particulate filters)	1 059
Air (charcoal cartridges)	360
Atmospheric moisture (molecular sieve)	212
Natural gas	14
Cryogenic (ground)	2
Compressed air (ground)	8
Compressed air (aerial)	21
Atmospheric moisture (freeze out)	30
Water	251
Precipitation	119
Milk	62
Natural vegetation	95
Soil	102
Food crops	95
Cow feed	55
Urine (residents)	113
Urine (EPA monitors)	94
Animal tissue and blood	17

[a] Tritium levels above normal background that were related to Project Rulison were detected in all types of offsite samples except water, milk, urine, animal tissue, food crops, and cow feed. Particulate filters and charcoal cartridges were not analyzed for tritium. The highest concentrations of tritium in offsite atmospheric moisture samples are shown in table 3.

Tritium levels above normal background that were related to Project Rulison were detected in all types of offsite samples except water, milk, urine, animal tissue, food crops and cow feed. Particulate filters and charcoal cartridges were not analyzed for tritium. The highest concentrations of tritium in offsite atmospheric moisture samples are shown in table 3.

Table 3. Five highest tritium concentrations in ε mospheric moisture samples, Rulison (molecular sieve collectors)[a]

Location (azimuth and distance from test well)	Date (1970)	Time (on-off)	Tritium (pCi/liter H_2O)	Concentration (pCi/m^3 air)
Special station A-IX (52°, 1.3 km)	10/5	0840–1040	59 000	290
Special station A-X (65°, 1.0 km)	10/5	0835–1035	51 000	240
Special station A-VII (15°, 1.3 km)	10/5	1452–1553	43 000	220
Special station A-X (65°, 1.0 km)	10/5	1450–1550	34 000	180
Special station A-IX (52°, 1.3 km)	10/5	1455–1555	27 000	150

[a] Tritium concentrations in atmospheric moisture samples from the Rulison area had a background range from 500 pCi/liter H_2O to 2 600 pCi/liter H_2O. The average was 1 000 pCi/liter H_2O. The AEC standard (AEC Manual, Chapter 0524) for continuous exposure of the general population to tritium is 67 000 pCi/m^3 of air.

Krypton-85 was detected in natural gas samples and in compressed air samples. The five highest concentrations of krypton-85 detected offsite in compressed air samples on the ground are listed in table 4. Background levels of krypton-85 in the Rulison area ranged from less than 5 pCi/m^3 to 14 pCi/m^3 of air with an average of 12 pCi/m^3.

Table 4. Five highest krypton-85 results for compressed air samples[a]

Location (azimuth and distance from test well)	Sampling period		krypton-85 concentration (pCi/m^3 air)
	Date (1970)	Time (on-off)	
Old control point pad (325°, 3.9 km)	10/28	0645–0710	47
Special station D-1 (286°, 7.4 km)	12/6	0851–0916	27
Special station D-11 (328°, 6.8 km)	12/3	1955–2025	20
Special station D-29 (76°, 26.5 km)	10/27	1720–1750	14
3 miles south of Rifle Airport (65°, 20.9 km)	12/70	1535–1600	12

[a] The AEC standard (AEC Manual, Chapter 0524) for the continuous exposure of the general population to krypton-85 is 1×10^5 pCi/m^3 air.

Baneberry, December 18, 1970

The Baneberry Event was an underground nuclear weapons test conducted at the NTS on December 18, 1970. Shortly after the detonation, fission products escaped into the atmosphere and were carried over the offsite area. A radiological monitoring program was conducted by the NERC-LV detected radioactivity in environmental media in a widespread area of the western United States.

External gamma exposures

All offsite external gamma exposure rate measurements at inhabited locations were less than 1 mR/h. The highest measured exposure rate at an unpopulated location was 1.2 mR/h about 1.6 km east of Queen City Summit on Highway 25.

Based on a $t^{-1.2}$ extrapolation of rate-meter data, an estimate of 36 mR as the highest estimated infinity exposure at a populated location (Clark Station) was reported in a final report (*3*). An algorithm was later developed, based on a generalized decay scheme of ground-deposited Baneberry activity. This algorithm provided extrapolation factors which indicated that 13 mR was a more appropriate estimate. From this algorithm for all measurements, the highest estimated infinite external gamma exposure at an inhabited location was determined to be 16 mR at Blue Jay Highway Maintenance Station, 106 km northeast of Tonopah, Nev., on Highway 6. Figures 7, 8, and 9 show the monitoring results from D—Day to D+10.

Environmental sampling

Figures 10 and 11 show the locations where environmental samples were collected and whether radionuclides were detected. The six water samples containing radioiodine were from open supplies not used for human consumption. The total number of each type of environmental sample collected is listed in table 5.

Table 5. Baneberry environmental samples

Type	Number of samples	Type	Number of samples
Milk	496	Precipitation	118
Water	92	Natural vegetation	72
Air (particulate filters)	225	Cow feed	118
Air (charcoal cartridges)	243		

Air sampling results

Table 6 shows the five highest air sampling

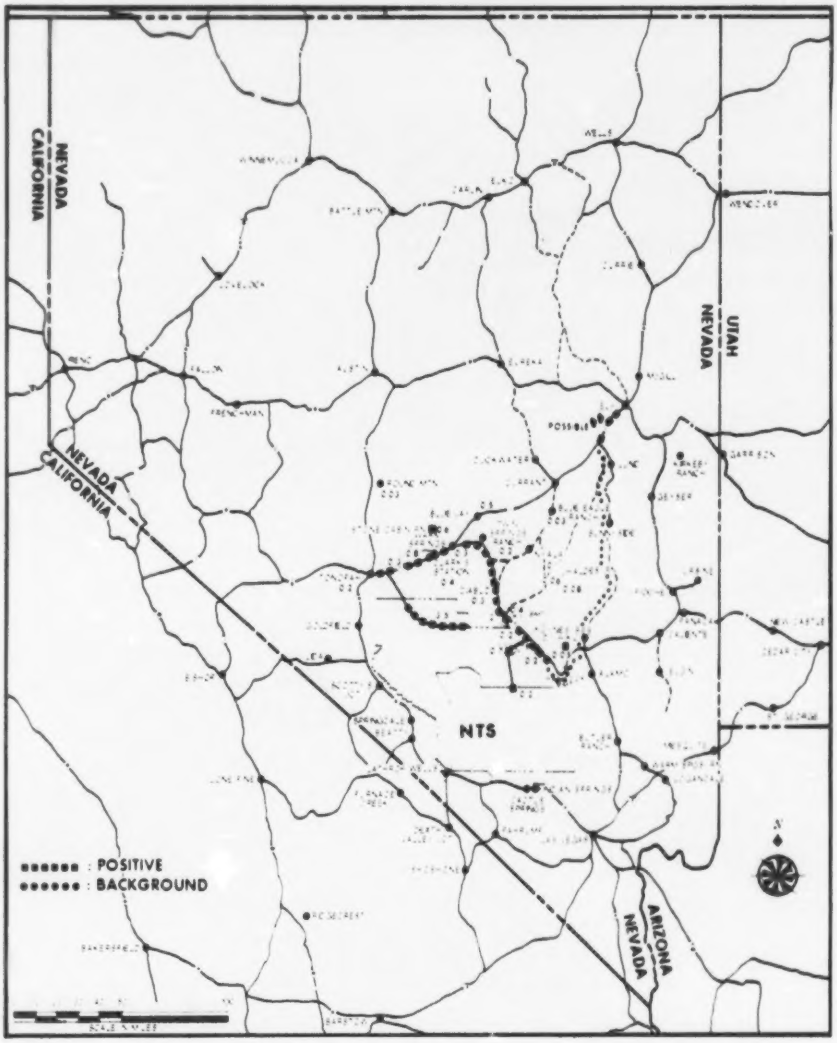
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
ARIZONA
NEVADA
NTS
POSITIVE
BACKGROUND
SCALE IN MILES

Figure 7. Area monitored and highest exposure rates (mR/h)-Nevada, Baneberry D-Day (12/18/70)

results ranked on the basis of maximum estimated thyroid dose to a hypothetical infant receptor with a 2-gram thyroid.

Milk sampling results

Table 7 shows the five highest milk sampling results ranked on the basis of the maximum estimated thyroid dose to a hypothetical infant receptor with a 2-gram thyroid. A 2-year-old child, living in Beatty, Nev., actually consuming milk from the McCurdy ranch was estimated to have received a dose of 130 mrem. The higher doses at the McCurdy ranch were the result of the cows grazing on pasture, whereas cows at other locations were eating hay. For the other ranches, the quantity of milk consumed by the youngest child drinking milk at each location was assumed to be 1 liter/day. The thyroid weights assumed for the 7- and 9-year-old children were 7 grams and 9 grams,

Table 6. Five highest estimated hypothetical infant thryoid doses from inhalation of radioiodine, Baneberry, December 1970

Nevada location (azimuth, distance from ground zero	Sampling period date/time		Time integrated radioactivity concentration [a] (μCi-s/m^3)				Estimated infant thyroid dose equivalent (mrem)
	on	off	^{131}I	^{132}I	^{133}I	^{135}I	
Stone Cabin Ranch [b] (337°, 120 km)	18/0800	30/0800	21	71	[c] 280	[c] 150	100
Austin (342°, 270 km)	18/1100	23/1000	[c] 12	31	[c] 150	50	53
Round Mountain (334°, 191 km)	18/1146	26/1140	7.4	18	[c] 85	[c] 27	31
Blue Jay maintenance station (356°, 137 km)	18/0740	28/0730	7.1	21	56	[c] 22	23
Tonopah (315°, 142 km)	18/1130	26/1400	[c] 4.5	[c] 8.2	[c] 48	35	19

[a] Extrapolated to end of collection periods.
[b] An electrical power failure between 0700 and 1200 on December 19 resulted in no sample collected for that period.
[c] Estimated concentration.

Table 7. Five highest estimated hypothetical infant thyroid doses from milk sampling results, Baneberry[a]

Location (azimuth and distance from ground zero	Date collected (1970)	Peak concentration of iodine-131 (pCi/liter)	Estimated infant thyroid dose equivalent (mrem)	Estimated thyroid dose equivalent to youngest individual actually drinking milk	
				(age)	(mrem)
McCurdy Ranch Springdale, Nev., (245°, 66 km)	12/26	810	260	2	130
Martin Ranch Eureka, Nev., (3°, 261 km)	12/22	240	40	>20	4
Young's Ranch Austin, Nev., (341°, 270 km)	12/21	140	30	9	7
Berg Ranch Round Mountain, Nev., (334°, 191 km)	12/21	70	20	7	5
Halstead Ranch Duckwater, Nev., (11°, 195 km)	12/20	90	10	>20	1

[a] Thyroid doses based on total milk samples collected, not on peak iodine-131 concentration.

respectively. A 20-gram thyroid weight was used for the adults. The thyroid dose equivalents received by the individuals were estimated from these assumptions, the concentrations of radioiodine in the milk and dose conversion factors.

Precipitation sampling results

Table 8 shows the five highest precipitation samples ranked by their concentrations of iodine-131. Normally, precipitation would not be of importance in terms of dose estimates. However, eight sheepherders working in an area between Duckwater and Eureka, Nev., were using melted snow for domestic purposes. Although no samples of the snow-water being used by the herders were collected, inference from samples collected around the area supports an estimated thyroid dose of 0.5 rem ± a factor of 3. The large error in the estimate is due to a number of uncertainties such as the geo-

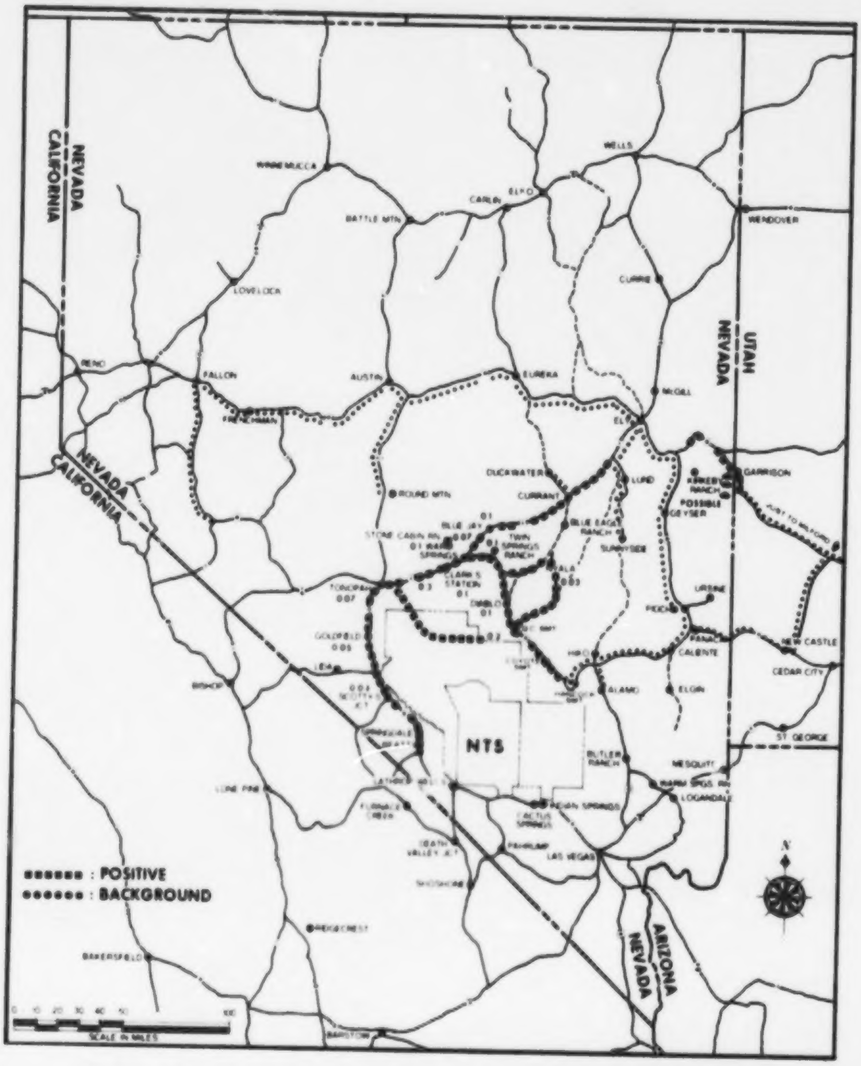
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
WINNEMUCCA
WELLS
ELKO
CARLIN
BATTLE MTN
WENDOVER
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
MCGILL
ELY
FRENCHMAN
DUCKWATER
LUND
GARRISON
ROUND MTN
CURRANT
POSSIBLE GEYSER
BLUE JAY
BLUE EAGLE RANCH
STONE CABIN RN
TWIN SPRINGS RANCH
SUNNYSIDE
TONOPAH
URSINE
PIOCHE
GOLDFIELD
PANACA
CALIENTE
NEW CASTLE
CEDAR CITY
BISHOP
HIKO
ALAMO
ELGIN
SCOTTYS JCT
ST GEORGE
NTS
BEATTY
BUTLER RANCH
MESQUITE
LONE PINE
LATHROP WELLS
LOGANDALE
FURNACE CREEK
INDIAN SPRINGS
CACTUS SPRINGS
DEATH VALLEY JCT
PAHRUMP
LAS VEGAS
SHOSHONE
RIDGECREST
BAKERSFIELD
BARSTOW
N
●●●●●● : POSITIVE
●●●●●● : BACKGROUND
0 10 20 30 40 50 100
SCALE IN MILES

Figure 8. Area monitored and highest exposure rates (mR/h)-Nevada, Baneberry D+1 (12/19/70)

graphical distribution of fallout, snow collection techniques, the dilution by new snowfall, the actual water content of snow, and whether the radioactivity was deposited on the surface by fallout or snowout.

Summary

Tritium released by the July through December 1970 flaring operations at Project Rulison was detected in all types of environmental samples collected on the ground in offsite areas except for milk, water, food, food crops, cow feed, urine, and animal tissue. The highest concentration of krypton-85 in air was less than 0.05 percent of the AEC standard, and the highest tritium concentration in air samples was less than 0.5 percent of the AEC standard for air in the AEC Manual, Chapter 0524 (4).

The only NTS event that released radioactivity into the offsite environment during this

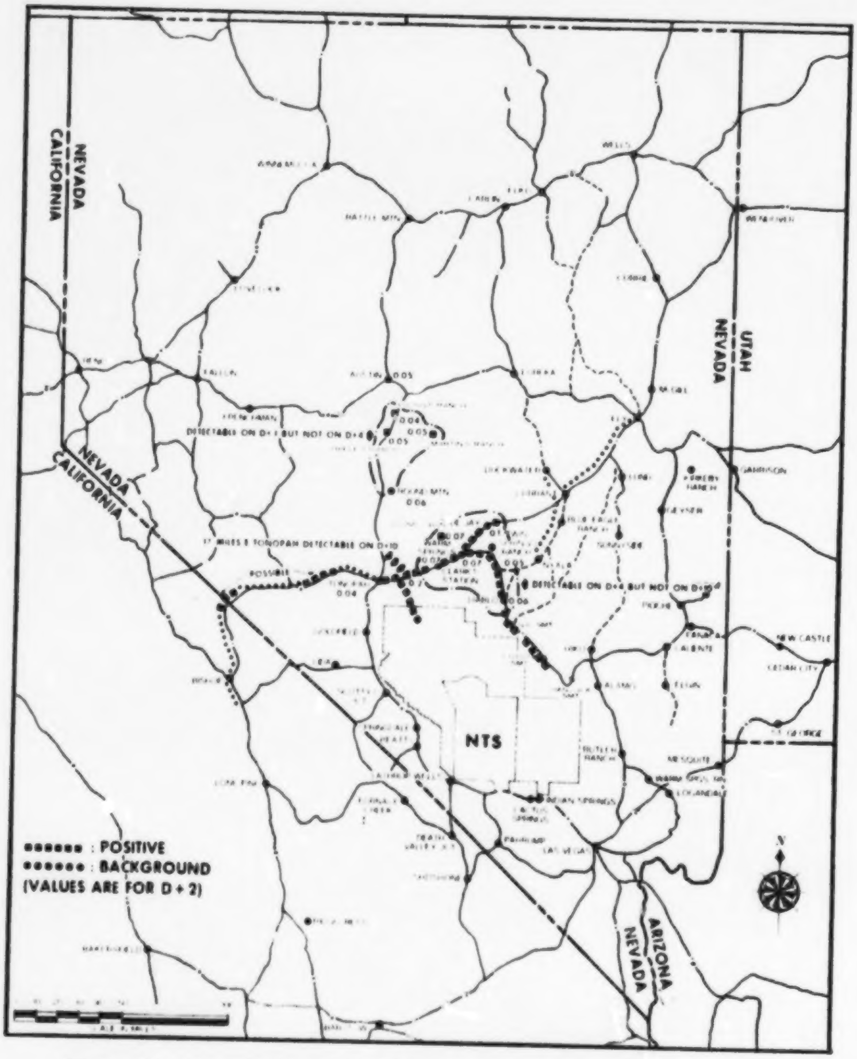
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
NTS
WELLS
CARLIN
BATTLE MTN
WENDOVER
FALLON
AUSTIN 0.05
EUREKA
ELY
0.04
0.05
0.05
DETECTABLE ON D+1 BUT NOT ON D+4
0.06
17 MILES E TONOPAH DETECTABLE ON D+10
0.04
0.07
0.07
0.07
0.05
0.2
0.06
DETECTABLE ON D+4 BUT NOT ON D+10
PIOCHE
CALIENTE
ALAMO
NEW CASTLE
CEDAR CITY
ST GEORGE
MESQUITE
INDIAN SPRINGS
PAHRUMP
LAS VEGAS
●●●●●● : POSITIVE
●●●●●● : BACKGROUND
(VALUES ARE FOR D + 2)
N

Figure 9. Area monitored and highest exposure rates (mR/h)-Nevada, Baneberry D+2-10 (12/20/70)

reporting period was Baneberry, on December 18, 1970. Figure 12 summarizes the combined estimates of hypothetical infant thyroid doses which were calculated from measured concentrations of airborne radioiodine, concentrations of radioiodine in milk, and external gamma radiation exposures. As shown by figure 12, the combined thyroid doses were below 0.5 rem, the radiation protection standard of AEC Manual, Chapter 0524 for thyroid doses to a representative population sample.

The highest estimated thyroid dose for Bane-

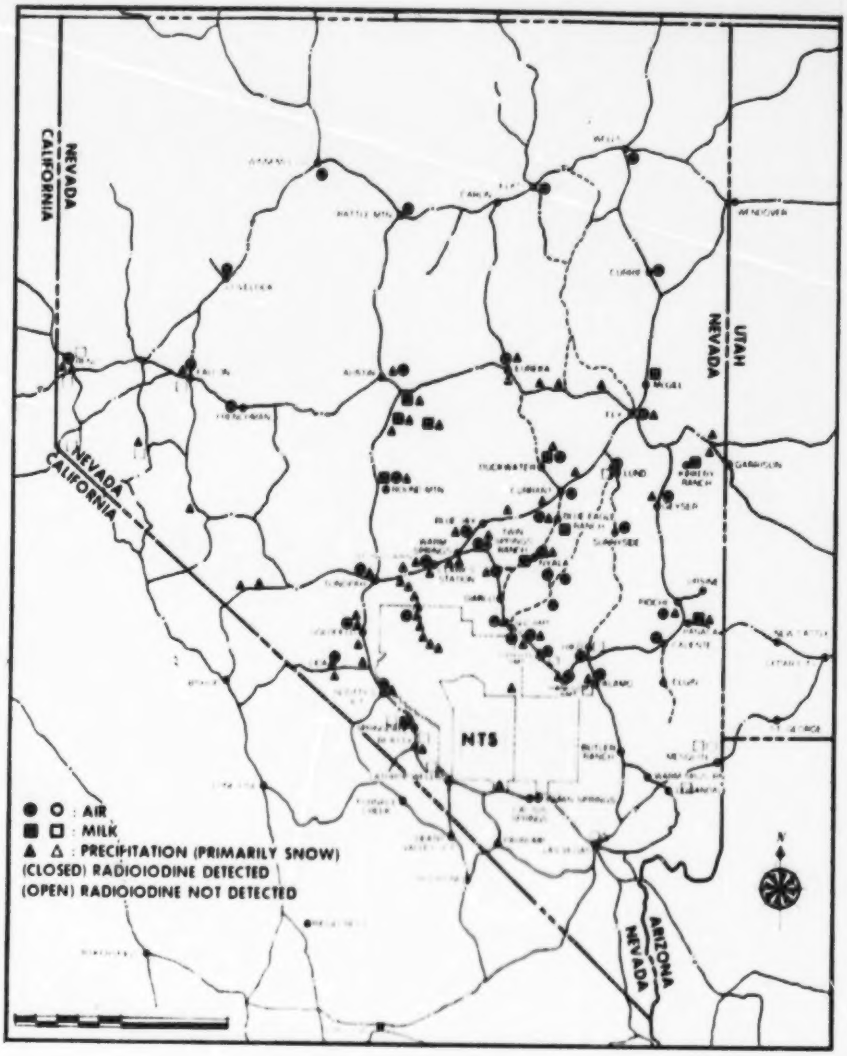
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
ARIZONA
NEVADA
NTS
N
● ○ : AIR
■ □ : MILK
▲ △ : PRECIPITATION (PRIMARILY SNOW)
(CLOSED) RADIOIODINE DETECTED
(OPEN) RADIOIODINE NOT DETECTED

Figure 10. Environmental sampling locations in Nevada, Baneberry

berry was for the sheepherders who were working between Eureka and Duckwater, Nev., and using snow for cooking and drinking. Although no snow being used by the herders was collected, inference from samples collected around the area supports a thyroid dose estimate of 0.5 rem ± a factor of 3, which is within the radiation protection standard (*4*) of 1.5 rem to the thyroid of an individual within the general population.

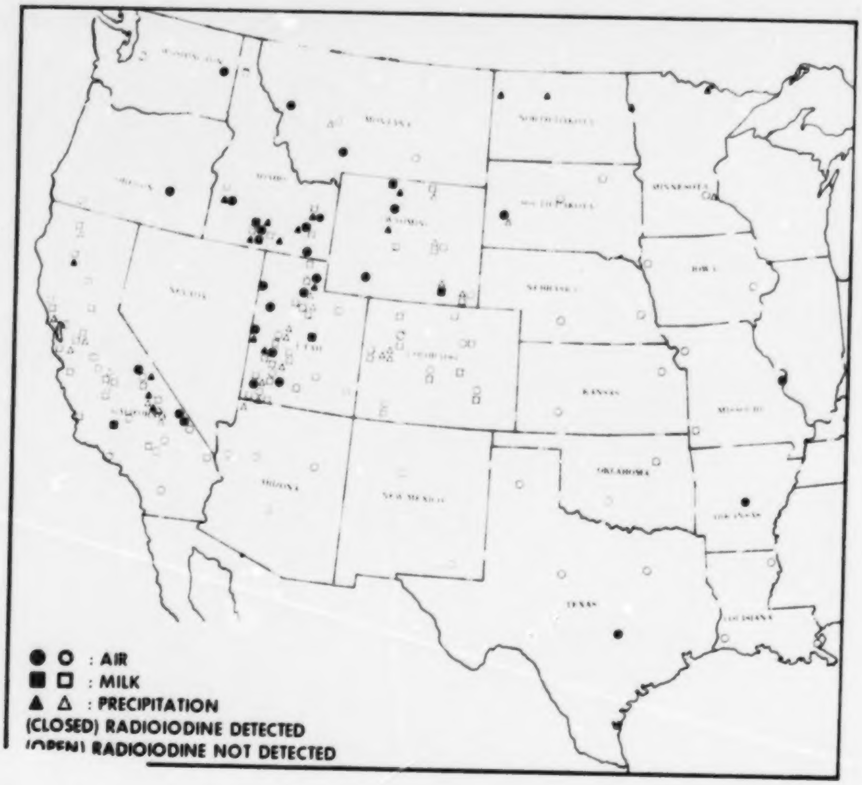
● ○ : AIR
■ □ : MILK
▲ △ : PRECIPITATION
(CLOSED) RADIOIODINE DETECTED
(OPEN) RADIOIODINE NOT DETECTED

Figure 11. Environmental sampling locations outside Nevada, Baneberry

Table 8. Five highest precipitation samples (snow) ranked by iodine-131 concentrations, Baneberry

Location (azimuth and distance from ground zero)	Date collected (1970)	Radionuclide concentration * (µCi/liter)			
		Iodine-131	Tellurium-132	Iodine-133	Iodine-135
Blue Jay maintenance station (355°, 142 km)	12/19	0.32	1.9	2.2	ND
24 km S junction highway 6 and TTR road (324°, 116 km)	12/19	.22	1.5	1.9	ND
48 km SW of Currant, Nev. on highway 6 (4°, 154 km)	12/20	.21	.99	.78	ND
Queen City Summit on highway 25 (8.5°, 71 km)	12/19	.20	.99	.54	.42
16 km S junction highway 6 and TTR road (323°, 122 km)	12/20	.19	.92	.92	ND

* Other radionuclides were detected but were not germane to thyroid dose calculations.
ND, nondetectable.

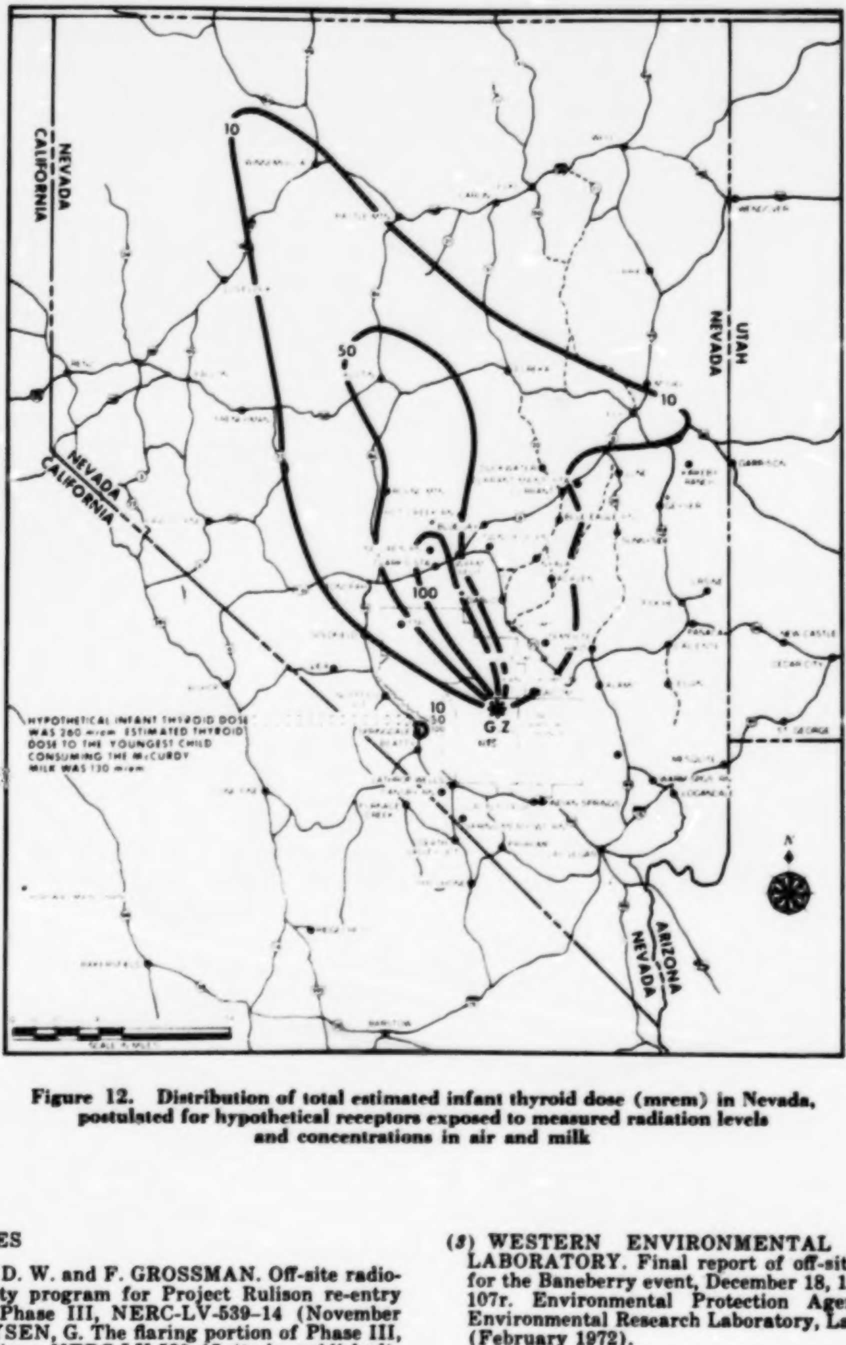
NEVADA
CALIFORNIA
UTAH
NEVADA
NEVADA
CALIFORNIA
ARIZONA
NEVADA
10
10
50
100
10
50
G Z
HYPOTHETICAL INFANT THYROID DOSE WAS 260 mrem ESTIMATED THYROID DOSE TO THE YOUNGEST CHILD CONSUMING THE McCURDY MILK WAS 130 mrem
N

Figure 12. Distribution of total estimated infant thyroid dose (mrem) in Nevada, postulated for hypothetical receptors exposed to measured radiation levels and concentrations in air and milk

REFERENCES

(*1*) PAYNE, D. W. and F. GROSSMAN. Off-site radiological safety program for Project Rulison re-entry portion of Phase III, NERC-LV-539-14 (November 1972); BOYSEN, G. The flaring portion of Phase III, Project Rulison, NERC-LV-539-15 (to be published).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Safety involving detonation of nuclear devices, NVO-28, Chapter 11. U.S. Atomic Energy Commission, Nevada Operations Office, Las Vegas, Nev. (May 1966, revised 1968).

(*3*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Final report of off-site surveillance for the Baneberry event, December 18, 1970, SWRHL-107r. Environmental Protection Agency, Western Environmental Research Laboratory, Las Vegas, Nev. (February 1972).

(*4*) U.S. ATOMIC ENERGY COMMISSION. Standards for radiation protection, AEC Manual, Chapter 0524. U.S. Atomic Energy Commission Washington, D.C. 20545 (November 8, 1968).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available from local AEC operations offices or from the National Technical Information Service at nominal cost. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports*. Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in the individual reports have been converted from the format required by the AEC to that used by *Radiation Data and Reports*. The Environmental Protection Agency has not independently nor critically reviewed the data or the conclusions derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Los Alamos Scientific Laboratory and Mound Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Los Alamos Scientific Laboratory[2] Calendar Year 1972

University of California
Los Alamos, New Mex.

The Los Alamos Scientific Laboratory (LASL), which is administered by the University of California for the U.S. Atomic Energy Commission (AEC), lies mostly in Los Alamos County, with only a small segment in Santa Fe County, and encompasses approximately 113 km^2. This parcel of AEC-controlled land contains all of the laboratory technical areas (figure 1).

The laboratory and community at Los Alamos are located on the Pajarito Plateau, situated west of the Rio Grande on the eastern slopes of the Jemez Mountains in north-central New Mexico. This land was originally chosen for its relative isolation. Thus, the area surrounding Los Alamos, including all of Los Alamos County and large portions of Sandoval, Rio Arriba, and Sante Fe Counties, is largely undeveloped except for those areas occupied by the laboratory facilities and associated communities. Large tracts of land in the Jemez Mountains to the north, west, and south of the laboratory site are held by the Forest Service. This land is largely covered by fir and aspen forests which support the usual variety of western mountain wildlife. Agriculture is limited to home gardens and some grazing of beef cattle. In the river valleys to the east, agriculture is restricted to relatively small plots supported by irrigation. Primary crops are chili peppers, tree fruits, and alfalfa. Milk is not produced in commercial quantities in the immediate vicinity of Los Alamos. The technical areas are principally located on the mesa tops with the interspersed canyons serving as separation areas, although a few have been located at the bottoms of steep, narrow canyons for isolation and safety purposes.

Airborne effluents

The major sources of airborne contaminants at LASL and the amounts of effluent from each

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[2] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites—Calendar Year 1972.

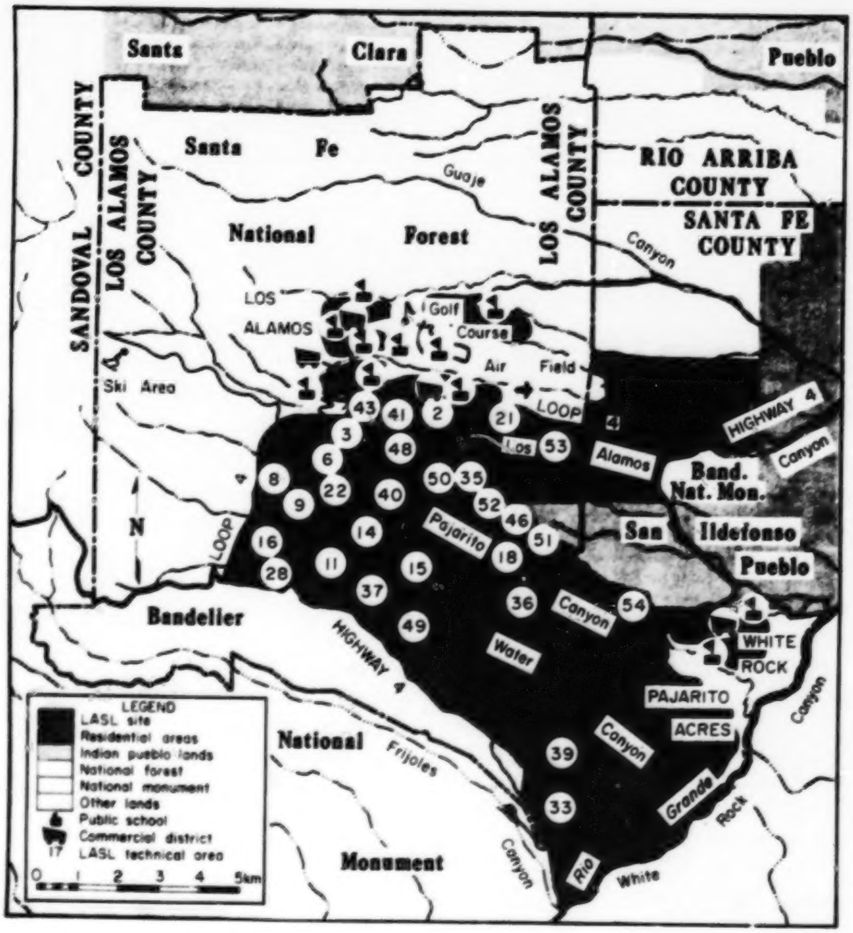

Santa
Clara
Pueblo
SANDOVAL COUNTY
LOS ALAMOS COUNTY
Santa Fe
Guaje
National
Forest
LOS ALAMOS COUNTY
RIO ARRIBA COUNTY
SANTA FE COUNTY
Canyon
LOS ALAMOS
Golf Course
Air Field
Ski Area
LOOP
HIGHWAY 4
Canyon
Los
Alamos
Band. Nat. Mon.
San Ildefonso Pueblo
N
LOOP
Pajarito
Canyon
Water
WHITE ROCK
PAJARITO ACRES
Bandelier
HIGHWAY 4
National
Frijoles
Canyon
Monument
Canyon
Grande
Rio
White
Rock
Canyon
43
41
2
21
53
3
48
6
8
22
40
50
35
9
52
46
14
51
16
18
28
11
15
37
36
54
49
39
33
LEGEND
LASL site
Residential areas
Indian pueblo lands
National forest
National monument
Other lands
Public school
Commercial district
17 LASL technical area
0 1 2 3 4 5km

Figure 1. Los Alamos County and LASL technical areas

source are summarized in table 1. The "other" category in table 1 accounts for certain conventional explosive tests conducted in accordance with strict safety precautions by M (Dynamic Testing) and WX (Weapons Engineering) Divisions at firing sites remote from other occupied laboratory sites and from residential areas. Most of the debris from these tests is deposited in the immediate vicinity of the prepared firing site, and little of the hazardous material is widely dispersed into the environment. A program to measure these dispersal fractions is currently under review, but execution will depend on funding and availability of manpower.

Liquid effluents

Most of the liquid effluent streams of the laboratory are comprised of cooling water and sanitary sewage. The effluents are released into canyons that contain intermittent streams that recharge water in the alluvium. This water is depleted by evaporation and transpiration and does not reach the Rio Grande. None of the effluent streams recharges aquifers from which municipal, industrial, or irrigation waters are drawn.

The primary contaminated, or potentially contaminated, liquid effluents from LASL operations are collected by an elaborate system of

Table 1. Summary of major airborne effluents, LASL, January-December 1972

Technical area	Unidentified		^{239}Pu, ^{238}Pu (µCi)	^{234}U, ^{235}U (µCi)	Depleted ^{238}U [c] (µCi)	^{131}I (Ci)	^{88}Rb, ^{138}Cs (mCi)	^{133}Xe, ^{135}Xe (Ci)	^{41}Ar (Ci)	^{3}H (Ci)
	Alpha [a] (µCi)	Beta [b] (µCi)								
2	—	—	—	—	—	—	47	720	640	—
3	680	6700	7900	100	260	7400	—	—	—	48
9	—	—	—	—	—	—	—	—	—	70
21	<1	<1	2800	1200	—	—	—	—	—	—
33	—	—	—	—	—	—	—	—	—	2900
35	—	—	18	—	—	—	—	—	—	2500
41	10	—	—	—	—	—	—	—	—	110
43	5	—	—	—	—	—	—	—	—	—
46	—	—	—	120	—	—	—	—	—	—
48	—	2700	110	8	—	—	—	—	—	—
50	—	140	27	—	—	—	—	—	—	—
Other	—	—	—	—	[d] 870	—	—	—	—	1800

[a] Primarily thorium-232, uranium-234,235,238, plutonium-238, and americium-241.
[b] Primarily mixed fission products.
[c] Depleted uranium of varying compositions.
[d] Kilograms, correspond to approximately 0.32 Ci. This amount not completely dispersed into the environment.

acid sewers and are treated at the industrial liquid waste treatment plant at TA–21 or the central industrial liquid waste treatment plant at TA–50. Effluents from the TA–21 treatment plant are released into DP Canyon, a tributary to Los Alamos Canyon, and the effluents from TA–50 are released into Effluent Canyon, a tributary to Mortandad Canyon. Only waters with concentrations lower than those listed in table 2 (i.e., in uncontrolled areas), AEC Manual Chapter 0524 are released, but evaporative and adsorptive processes tend to concentrate the contamination in the channel alluvium. The amounts of radionuclides released from these two sources are shown in table 2.

Table 2. Summary of major liquid effluents LASL, January-December 1972

Contaminant	TA-21	TA-50
Volume discharged 10^6 liters	8.8	57
Radioactivity: (mCi)		
Gross alpha	.93	14
Plutonium-238	.16	7.7
Plutonium-239	.10	1.0
Gross beta	16	380
Strontium-89	.65	3.5
Strontium-90	1.0	5.5
Tritium	3 600	6 000

Solid waste

Although the disposal of solid radioactive wastes is not directly pertinent to an environmental monitoring program, wastes improperly controlled in disposal could have a most significant environmental impact. A short summary of LASL disposal activities is included here for this reason, and to present a more complete picture of the laboratory's waste treatment effort, as well as to convey an idea of the actual amounts of solid waste generated.

Solid wastes, consisting mostly of contaminated sludges from the industrial liquid waste treatment plants and potentially contaminated refuse from routine laboratory operations, are buried in pits at TA–54 on the Mesita del Buey and in shafts at TA–21. These locations were chosen in consultation with the U.S. Geological Survey to assure long-time localization of radioactivity. Large pits are nominally 30 m wide by 180 m long by 9 m deep, and smaller ones are 15 by 90 by 9 m. The shafts at TA–21 are nominally 2.5 m in diameter and 5 to 20 m deep. They are asphalt-lined and do not penetrate to the water table, which is over 350 m below the surface at TA–21.

The quantities of materials placed in storage during 1972 are given in table 3. The total quantity of radioactive material in several of the categories is not estimated because individual consignments are below the limits of detection for any device to measure gross activity, and to multiply the large waste volumes by any assumed value for the possible concentration of radioactivity would be false and misleading. Laboratory accountability procedures, developed over many years, give assurance that only small quantities of radioactive materials are contained in laboratory trash and scrap.

Table 3. Summary of solid waste disposal, LASL, January-December 1972

Nature of waste	Container or stabilizer	Estimated volume (liters)	Estimated activity (Ci)
Contaminated sludge from TA-50 liquid waste treatment plant	Metal drums	260 000	9
Contaminated sludge from TA-21 liquid waste treatment plant [a]	Cement paste	530 000	300
Hot cell and glovebox wastes containing uranium, plutonium, and fission products	Metal containers, wooden crates	16 000	79
Activated metal	Metal containers	340	15
Tritium and tritium contaminated wastes	Metal containers, concrete	8 700	2000
Uranium and uranium contaminated wastes	Metal containers, wooden crates	39 000	Not estimated
Plutonium and plutonium contaminated wastes	Metal containers, wooden crates	83 000	Not estimated
Contaminated animal tissue	Cardboard boxes	450	Not estimated
Low level sources	Metal containers	350	<1
Laboratory trash	Cardboard boxes, plastic bags	1 800 000	Not estimated
Metal scrap	Not packaged	1 600 000	Not estimated
Classified	Metal drums	16 000	Not estimated

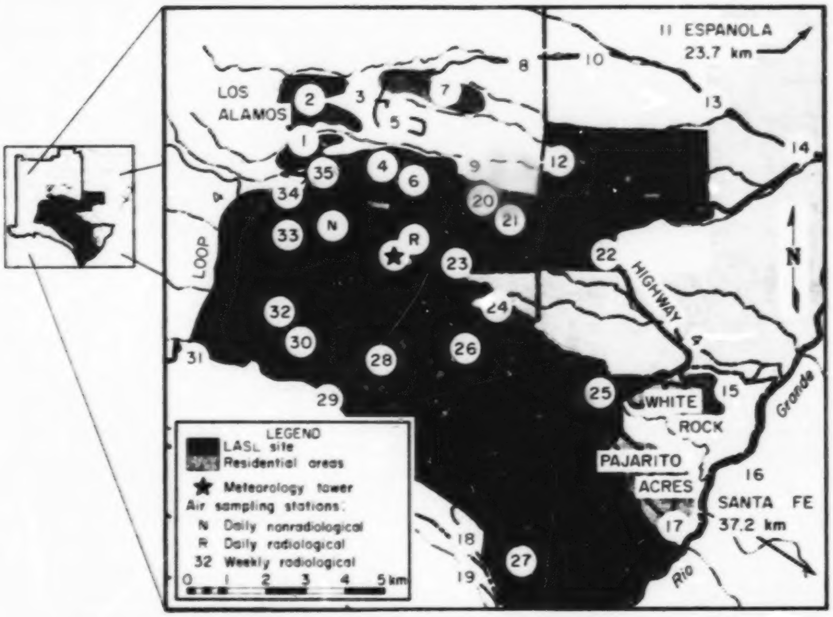
[a] Placed in shafts at TA-21.

Atmospheric monitoring program

The air monitoring program is designed to provide for general surveillance of the levels of gross alpha and beta radioactivity in air, the concentrations of those specific radionuclides directly associated with laboratory operations, and the concentrations of certain nonradioactive materials.

Daily air sampling

An air sampler drawing air through a 78-mm Microsorban filter having an efficiency of about 99.8 percent for 0.3-μm dioctylphthalate (DOP) particles (a standard test aerosol for determining filter efficiency) and an 80-mm Welsh charcoal respirator cartridge at a rate of approximately 200 liters/min is maintained on the roof of Building LD-1, TA-50. The filter and the canister are changed daily. The particulate material on the filter is measured on the day of collection for gross alpha and beta emissions on an alpha-beta gas flow proportional counter and again 7 to 10 days after collection to measure long-lived activity. The initial measurements of the gross alpha and beta emissions provide an early detection of


11 ESPANOLA
23.7 km
LOS ALAMOS
1
2
3
4
5
6
7
8
9
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14
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20
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22
23
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25
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27
28
29
30
31
32
33
34
35
N
R
LOOP
HIGHWAY 4
WHITE ROCK
PAJARITO ACRES
SANTA FE
37.2 km
Rio Grande
LEGEND
LASL site
Residential areas
Meteorology tower
Air sampling stations:
N Daily nonradiological
R Daily radiological
32 Weekly radiological
0 1 2 3 4 5 km

Figure 2. Locations of atmospheric monitoring stations, Los Alamos

high activities relative to natural background levels. The 7-day measurements, after the decay of radon and thoron daughters, are used as the official records of activity. The alpha activity is consistently at or near the MDL of the system, approximately 1 fCi/m^3, and is not reported here. The sensitivity of the system is adequate to give early warning of a significant accidental release, should one occur. The long-lived gross beta activity measurements for 1972 are comparable with national samples collected by the Environmental Protection Agency (EPA) (*1*), and follow cyclic trends established by past years' data (*2,3*). This trend is due to seasonal changes in atmospheric mixing that bring fission products from past atmospheric weapons testing to the ground. The pronounced peaks in mid-January and late March are the results of Chinese atmospheric nuclear tests of January 7 and March 18.

The activity collected by the charcoal canister is measured by gamma-ray spectrometry for iodine-131. None of the charcoal cartridges contained iodine-131 at a level of more than 10 fCi/m^3, the estimated MDL of the system. Locations of atmospheric monitoring stations are shown in figure 2.

Daily deposition sampling

Deposition of gross beta activity on a 0.4-m^2 precipitation collector located at TA–50 is measured each workday. The collector is rinsed with water combined with whatever precipitation may have been collected. This water is filtered through a Whatman 41 filter and the gross beta activity of the filter and filtrate are measured separately to determine the "soluble" component of the deposition activity. This separation is conducted to provide data for other studies, however, and for surveillance purposes, the two results are added and reported as total gross beta activity. A measurement is made immediately to augment the daily air sample data and again after 7 days to represent the long-lived gross beta activity free of radon and thoron products.

Weekly air sampling

The main air monitoring program consists of a weekly sample collection from 35 continuous air sampling stations. An extensive revamping in 1971 resulted in a network that required no major changes during this reporting period, and virtually the entire array was operative during the entire period, giving 51 weekly samples for all but a few stations. Each station consists of a pump that pulls air through a Microsorban filter and a Welsh charcoal cartridge similar to those used to collect the daily sample. During the latter part of this reporting period, a program to replace some of the older and more troublesome pumps with new pumps of higher capacity and requiring less maintenance resulted in two different flow rates. The flow rate as measured by rotometers, was 70 liters/min except for six new pumps whose rate was 200 liters/min.

On the first and tenth day after collection, each filter is measured simultaneously for gross alpha and beta activities by a gas flow proportional counter. The first-day count is for 30 minutes, and the tenth-day count is for 90 minutes. Results of gross measurements on weekly air filters are shown in table 4.

Gross activity

The gross alpha and gross beta activities are measured to maintain a historical record of these activities and for screening of the samples to detect unexpectedly high concentrations of radionuclides not covered by more specific analyses.

The gross alpha measurements have been corrected both for background of the counting chamber and for the approximately 0.1 percent of beta counts that feed into the alpha channel of the counter (cross-talk). Background, i.e., count of an unused filter (blank), normally runs 33 counts/90 minutes. A filter from the sampling array can thus be distinguished from the blank if it contains a total activity of more than 44 counts/90 minutes. Consideration of total flow through the filter yields an MDL of about 0.2 fCi/m^3 for the total collection (old pumps) and analysis procedure.

The average gross alpha measurements for the 35 stations were higher than those reported previously; however, the increase was not due to local sources, but to the 1972 Chinese tests.

Table 4. Results of gross measurements on weekly air filters, LASL, January-December 1972

Station	Gross alpha concentration (fCi/m³)		Gross beta concentration (fCi/m³)	
	Maximum	Average [a]	Maximum	Average [a]
Offsite:				
1	4.2	1.6±0.2	1.68	0.19±0.08
2	3.6	1.6± .3	2.19	.18± .09
3	4.6	1.5± .3	1.55	.20± .10
4	4.7	1.6± .3	2.44	.19± .10
5	4.5	1.7± .3	1.83	.19± .09
6	6.0	1.4± .3	2.20	.20± .10
7	3.6	1.6± .2	1.99	.19± .09
8	4.8	2.0± .3	2.60	.18± .10
9	6.4	1.9± .4	1.95	.20± .10
10	4.6	1.9± .3	3.19	.20± .13
11	6.2	[b] 2.1± .5	2.57	[b] .19± .11
12	7.6	1.6± .4	1.65	.19± .08
13	4.7	1.7± .3	2.94	.19± .12
14	3.7	1.7± .2	1.59	.22± .10
15	4.3	1.6± .3	1.64	.18± .07
16	7.2	[c] 2.0± .4	1.92	[c] .18± .08
17	4.2	1.3± .3	1.90	.19± .08
18	4.5	1.4± .2	2.19	.18± .09
19	4.4	1.5± .2	3.27	.18± .08
Onsite:				
20	2.8	1.3± .2	1.41	.17± .06
21	7.5	2.2± .4	1.86	.19± .09
22	5.3	1.5± .3	1.76	.18± .08
23	9.5	[b] 1.6± .4	1.87	[b] .20± .09
24	4.0	1.5± .2	2.03	.20± .10
25	4.5	1.6± .3	1.77	.18± .07
26	3.5	1.1± .2	2.03	.17± .09
27	9.8	1.9± .6	3.27	.21± .13
28	3.5	1.3± .2	2.14	.20± .10
29	4.4	1.5± .3	2.32	.19± .10
30	3.7	1.2± .2	2.08	.18± .08
31	4.7	1.5± .3	2.27	.19± .10
32	3.4	1.1± .2	1.76	.18± .08
33	5.2	1.5± .3	2.15	.20± .10
34	4.0	1.5± .3	1.94	.17± .08
35	5.3	1.5± .3	2.14	.18± .09

[a] Average and 95-percent confidence limits for the average.
[b] One sample lost.
[c] Two samples lost.

The maximum alpha activity observed at every station occurred during the detection of one or the other of the two Chinese tests. Because of the difficulty in determining when the effects of these tests had become negligible, all values were included in the averages given in the table. No local releases of significant magnitude were observed. Spatial variations in gross alpha activity measured at all 35 stations can be described by a log normal distribution (normal distribution of the logarithms of the numbers) and its associated random fluctuations. This lack of significant station effects, along with the small range in concentrations, leads one to conclude that the laboratory has little influence on the level of this activity.

The gross beta averages, given in table 4, are higher than previously reported. Again, the maximums, and hence the inflated averages, were due to Chinese tests, and no local discharges were observed. The seasonal trend, reported previously (*2,3*) was also observed with the weekly sample data. Results of measurements at all 35 stations are again log normally distributed, reflecting the small influence of laboratory activities on this level.

The gross beta measurements were corrected only for counter background because the cross-talk from the alpha channel is negligible. Background levels for the counter (blank count of 680/90 minutes), together with sampling techniques, result in an estimate of 0.7 fCi/m³ for the MDL of the gross beta activity.

The charcoal cartridges collected with the weekly particulate samples are analyzed for iodine on a gamma-ray spectrometer. Analysis of the cartridges indicated that iodine-131 could not have been present at concentrations above 10 fCi/m³, the estimated MDL of the system.

Plutonium and americium

The weekly filters, after being measured for gross alpha and beta activities, are combined

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Table 5. Plutonium and americium concentrations in air, LASL, January-December 1972

Station	Concentration (aCi/m³)					
	Plutonium-238		Plutonium-239		Americium-241	
	Maximum	Average	Maximum	Average	Maximum	Average
Offsite:						
1	34	17	363	69	—	—
2	194	32	160	47	—	—
3	350	41	117	40	—	—
4	117	31	104	43	—	—
5	70	24	191	50	—	—
6	33	14	108	35	—	—
7	37	15	148	46	—	—
8	73	19	87	36	—	—
9	209	28	265	73	—	—
10	68	25	197	47	—	—
11	19	14	108	38	—	—
12	136	29	122	37	—	—
13	31	16	126	47	—	—
14	46	19	89	41	—	—
15	99	22	186	61	—	—
16	26	[b] 14	73	[b] 33	80	[a] 27
17	48	19	105	38	—	—
18	59	[b] 17	144	[b] 31	—	—
19	36	[b] 16	101	[b] 28	—	—
Onsite:						
20	176	31	112	53	—	—
21	53	19	148	45	178	44
22	42	17	113	32	—	—
23	81	25	112	43	—	—
24	241	34	106	38	—	—
25	47	17	143	37	—	—
26	51	12	136	45	—	—
27	37	18	99	37	—	—
28	49	19	89	32	61	22
29	52	20	241	56	—	—
30	59	18	99	30	87	33
31	94	21	101	34	—	—
32	58	21	76	36	97	40
33	133	28	930	117	—	—
34	404	80	224	58	88	[b] 32
35	257	50	122	50	—	—

[a] Includes one 3-week sample and twelve 4-week samples.
[b] One sample lost.
[c] Two samples lost.

to represent a 4-week sample from each station and are analyzed radiochemically for plutonium-238, -239. Composite 4-week samples from 6 of the stations are also analyzed for americium-241. The MDL is about 0.1 fCi/m³ for each of the three isotopes. These concentrations are summarized in table 5. At least one measurement at each station fell below the MDL.

The plutonium-238 levels measured during this period followed established patterns. The highest concentrations occurred north and east of TA–21 and the CMR Building (TA–3) where releases of filtered process air containing traces of plutonium occurred.

The maximum plutonium-238 onsite average concentration, 80 aCi/m³ at station 34 (TA–3) was 0.004 percent of the 2 pCi/m³ concentration guide value for the soluble form of the isotope, as listed in AEC Manual Chapter 0524, for a controlled area. The maximum offsite average concentration, 41 aCi/liter at station 3, Los Alamos Golf Course, was 0.06 percent of the 70 fCi/m³ value for uncontrolled areas. The maximum 1-month concentration occurred at this same station and was 0.5 percent of the uncontrolled area guide value. The highest average for the 35 stations occurred during the period in which the debris of the March 18 Chinese atmospheric nuclear test was detected. The overall average annual concentration for the 35 stations of the LASL air sampling network as 24 aCi/m³ as compared to an average annual value of 3.8 aCi/m³ for 10 reporting stations of the EPA Radiation Alert Network (*4–7*) across the United States during 1971.

The plutonium-239 measurements, not easily represented pictorially, also relate to the plutonium emissions from the CMR Building and TA–21. The maximum onsite average concentration, 120 aCi/m³ at station 33, TA–6, was 0.006 percent of the AEC Manual Chapter 0524 guide limit of 2 pCi/m³ for the soluble form of

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the isotope for controlled areas, and the maximum offsite average concentration, 73 aCi/m^3 at station 9, Los Alamos Airport, was 0.1 percent of the 60 fCi/m^3 guide limit for uncontrolled areas. The maximum offsite average for a given month, 360 aCi/m^3, occurred at station 1, Diamond Drive, and was only 0.6 percent of the uncontrolled area guide value. The overall average annual concentration for all 35 stations was 45 aCi/m^3 compared to an average value of 50 aCi/m^3 for the 10 reporting stations of the EPA Radiation Alert Network.

The highest average americium-241 concentration of the six stations routinely measured (44 aCi/m^3) occurred at station 21, TA–53, the station closest to TA–21, where americium-241 emissions may be expected in association with plutonium. This value was less than 0.001 percent of the AEC Manual Chapter 0524 concentration guide value of 6 pCi/m^3 for the soluble form of the isotope. The effort directed at measurement of this isotope will be studied in greater detail during 1973 in order to develop a more comprehensive program.

Table 6. Tritiated moisture and total moisture and total uranium concentrations in air, LASL, January-December 1972

Station	Tritiated moisture (pCi/m^3)		Total uranium (pg/m^3)	
	Maximum	Average	Maximum	Average
Offsite:				
1	83	25	100	90
2	43	21	90	70
3	77	22	180	110
4	120	29	80	60
5	87	29	170	110
6	94	31	180	100
7	71	23	110	60
8	80	23	120	90
9	190	36	80	60
10	86	23	150	80
11	36	20	180	110
12	57	24	90	60
13	68	22	130	80
14	65	21	100	70
15	89	25	120	80
16	46	21	90	80
17	68	23	110	70
18	650	44	90	60
19	60	22	170	90
Onsite:				
20	120	36	100	70
21	180	33	120	70
22	110	33	110	60
23	700	110	140	70
24	110	32	80	70
25	210	48	90	60
26	150	29	130	60
27	2 300	180	120	90
28	77	28	110	60
29	53	21	240	120
30	48	24	80	60
31	42	21	70	60
32	120	31	90	60
33	84	29	80	60
34	160	33	60	50
35	83	28	70	60

Uranium

An aliquot of each of the 4-week composite samples was saved to form a 12-week composite which was analyzed fluorometrically for uranium. The MDL of the system, which does not distinguish separate uranium isotopes, is about 50 pg/m^3. Although depleted uranium is involved in LASL explosive tests, there does not appear to be a station effect with distance from the areas of the explosive testing. The concentrations, given in table 6, are approximately 50 percent lower than those reported for the last 6 months of 1971.

Tritium

In addition to the particulate sample and the iodine-131 sample, a separate sample is collected at each station every week for tritium measurement. Air is drawn through a tube of silica gel dessicant at an average flow of approximately 50 ml/minute. This procedure permits water vapor collection at about 95-percent efficiency. The water vapor is collected by heating the dessicant and condensing the resulting vapor. A standard aliquot of this water is analyzed for tritium content by liquid scintillation counting and the resulting figure is combined with the average humidity for the week to obtain an estimate of the average tritiated vapor content per unit volume of air. The collection system and counting procedure result in an MDL of approximately 5 pCi/m^3 (50 percent relative humidity, 9°C temperature, 750 mbar pressure).

Measurements of tritiated water vapor in air are summarized in table 6. At least one measurement at each station fell below the MDL. As expected, the highest concentrations were near TA–33 and TA–35 due to tritium releases (table 1). The highest average for an onsite station, which occurred at station 27, TA-33, was 0.004 percent of the concentration guide value for controlled areas (5 μCi/m^3), as listed in AEC Manual Chapter 0524. The highest average for an offsite or uncontrolled area occurred at station 9, Los Alamos Airport and was 0.02 percent of the AEC recommended guide of 0.2 μCi/m^3 for uncontrolled areas.

External radiation monitoring program

A thermoluminescent dosimeter (TLD) array is maintained to monitor gamma and x radiation at natural background levels to provide information on any possible contribution from laboratory activities.

Each of the 59 stations in the array is composed of three Harshaw TLD–100 chips. These are cut from single crystals of LiF (natural lithium) and are 3.18 mm square by 0.89 mm thick, with a mass of 23 to 24 mg. The three chips are wrapped together in aluminum foil and put in a 17-mm diameter by 50-mm long cylindrical polyethylene container for placement in the field. The TLD's in the field are exchanged with fresh ones at regular periods and the thermoluminescence is measured by means of an Eberline TLR–5 reader. The exposure of each chip is inferred, using identical calibration chips that have received known exposures from a cobalt-60 source under controlled conditions. The average of the three exposures is then taken to give the total exposure for the period of the exchange at the particular station.

The stations were operated on a 4-week exchange schedule for the first 24 weeks of 1972, starting January 12. Operating experience revealed that the exchange interval could be relaxed to 12 weeks for 45 of the 59 stations. The last exchange for which data are available for this report took place December 12, giving 48 weeks of data for the year.

In general, there was very little temporal variation in exposure rate, which remained fairly constant over the year at approximately 13 mR/month.

Table 7. Summary of thermoluminescent dosimeter readings, LASL, January-December 1972

Station	Exchange interval (wk)	Annual exposure (mR)
Offsite:		
1	12	130
2	12	146
3	4	124
4	12	156
5	12	141
6	12	196
7	12	153
8	4	133
9	12	194
10	12	148
11	4	187
12	12	137
13	12	111
14	12	179
15	12	141
16	4	141
17	12	138
18	4	127
19	12	145
20	4	123
21	12	174
22	4	229
Average[a]		147
Range		137–157
Onsite:		
23	12	117
24	4	203
25	12	124
26	4	139
27	12	135
28	12	244
29	12	173
30	12	152
31	12	188
32	12	189
33	4	597
34	12	188
35	4	339
36	12	174
37	12	215
38	12	236
39	12	174
40	12	155
41	12	153
42	12	181
43	12	161
44	4	193
45	12	151
46	12	153
47	12	152
48	12	166
49	4	162
50	12	158
51	12	147
52	12	156
53	12	167
54	12	134
55	12	163
56	4	157
57	12	150
58	12	162
59	12	149
Average[a]		160
Range		152–168
All stations:		
Average[a]		155
Range		149–161

[a] Geometric mean. Range gives the 95-percent confidence limit for the average, and was calculated from the geometric standard deviation. Stations 22, 28, 33, 35, and 38 are not included in these calculations.

Total exposures for calendar year 1972 at the 59 TLD stations in the Los Alamos area were estimated from the 48 weeks of data and are presented in table 7. The spatial variation can be accounted for by statistical fluctuations about a central mean value, except for five stations. These stations, one offsite and four onsite, are discussed later and are excluded from the following argument. It can be shown statistically that these exposures fit a log normal distribution function reasonably well, a result consistent with the results of many other environmental measurements. A geometric mean of 147 mR and a geometric standard deviation of 1.17 (multiplicative) are obtained for the 21 offsite stations, with corresponding values of 160 mR and 1.14 for the 33 onsite stations under consideration. Furthermore, these means are statistically equal at the 95 percent level of confidence, so that the entire group of results may be adequately described by a single log normal distribution with a geometric mean of 155 mR and a standard deviation of 1.16. The lack of significant station effects indicates that this level of external radiation is caused by natural terrestrial and solar sources, the variation being due to the random nature of these sources. For comparison, TLD-measured exposure at Colorado Springs (elevation 1880 m) is reported (*8*) to be about 143 mR/yr, and the range at locations closer to sea level is likely to be 25 to 80 mR/yr, depending on geology.

The single offsite station not included in the above discussion is located at the headquarters complex of Bandelier National Monument (station 22). This station indicated slightly higher levels than the other stations during the July–December 1971 reporting period as well. None of the air samples collected at the same station indicated any unusually high levels of airborne radioactivity. It is very doubtful that the response to the TLD's at this station is due to laboratory activities. It is probably due to a combination of two effects: first, a slightly higher than normal contribution from naturally occurring terrestrial gamma-emitting radionuclides; and second, the geometry of the station. The station is located next to an adobe-brick wall at the bottom of a 175-m deep canyon which is about 350 m wide.

Of the four onsite stations mentioned above, two stations: 33, TA–18 and 35, TA–36; are positioned so as to monitor TA–18. Their reresponse is due solely to operation at TA–18 of fast burst reactors (research reactors that are operated in such a manner as to provide very short and very intense bursts of neutrons). A third, station 38, TA–39 is located near the base of a cliff approximately 75 m high. No air sampler is located at this station for comparison, but the somewhat elevated level reported during 1971 indicates that terrestrial sources, mentioned in the preceding paragraph, could quite possibly account for the high measurement. The cause of the high measurement at the remaining station, station 28, Highway 4, is unexplained. No air sampler is located there, and a high TLD indication was not reported during 1971. It is doubtful that laboratory activities influenced either of the latter two results. The three stations whose results are not clearly understood will be studied further by use of field instrumentation and by small displacements of the TLD packets from their usual positions.

Water monitoring program

The water monitoring program is designed for surveillance of the Los Alamos municipal water supply drawn from the deep aquifer underlying the laboratory area, as well as for general surveillance of the ground and surface waters in the vicinity. Samples from supply wells are collected at the individual wellheads during pumping, and samples of surface water are bailed from a convenient pool or allowed to flow directly in to the sample container. For samples from observation holes and test wells, sufficient water is drawn and discarded to make the sample representative of the ground water at the time of sampling. All samples are analyzed by radiochemical methods for gross alpha, beta, and gamma activities and for tritium, plutonium, and cesium-137. A fluorometric technique is used to measure uranium concentration.

The plutonium determination performed on these water samples deserve special mention because tenuous identifications of trace amounts of this material were made on several occasions. These identifications are believed to be due to cross-contamination in the analytical laboratory or to fluctuations of the MDL, both very real problems at the low concentrations being investigated here. Thus, those samples in which traces of plutonium were found are reported, although they are probably not indicative of actual plutonium contamination of the water from which they were taken. Verification will depend upon patterns established by analyses of future sample collections.

Los Alamos water supply

During 1972, about 6.8 billion liters of water were supplied to Los Alamos from 16 supply wells ranging in depth from 265 to 795 m and from one gallery which has been developed on the eastern flanks of the Jemez Mountains.

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**Table 8. Analyses of Los Alamos water system samples, LASL
January-December 1972**

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Gross alpha (pCi/liter)	35	20	<2.0	<2.1	1.0
Gross beta (pCi/liter)	35	11	<1.0	<3.0	1.0
Plutonium-238 (fCi/liter)	36	<50	<50	<50	50
Plutonium-239 (fCi/liter)	36	<50	<50	<50	50
Cesium-137 (pCi/liter)	35	<350	<350	<350	350
Tritium (nCi/liter)	35	<1.0	<10	<1.0	1.0
Total uranium (ng/liter)	35	25 000	<200	<2900	200

These sources, as well as two test wells, were sampled to monitor the quality of water in the main aquifer. The range and average of constituents in this water are given in table 8.

There is a slight variation in water quality from periods of light pumpage (winter) to periods of heavy pumpage (summer).

Regional surface waters

Offsite rivers and reservoirs in and adjacent to the Los Alamos area are sampled and analyzed routinely to provide information on general water quality in the area and to serve as background for other measurements. During this period, 16 water samples were collected at four river stations: the Rio Chama at Chamita, and the Rio Grande at Embudo, Otowi, and Cochiti (figure 3). Sixteen water samples (two at each station) were taken from the other stations at Caliente River, Santa Cruz Reservoir, Tesuque Creek, Galisteo Reservoir, the Rio Grande at Bernalillo, Jemez Creek, Fenton Lake, and Abiquiu Reservoir. Only one sample was collected from Jemez Reservoir. These nine stations are 35 to 50 km from the approximate center of the LASL site.

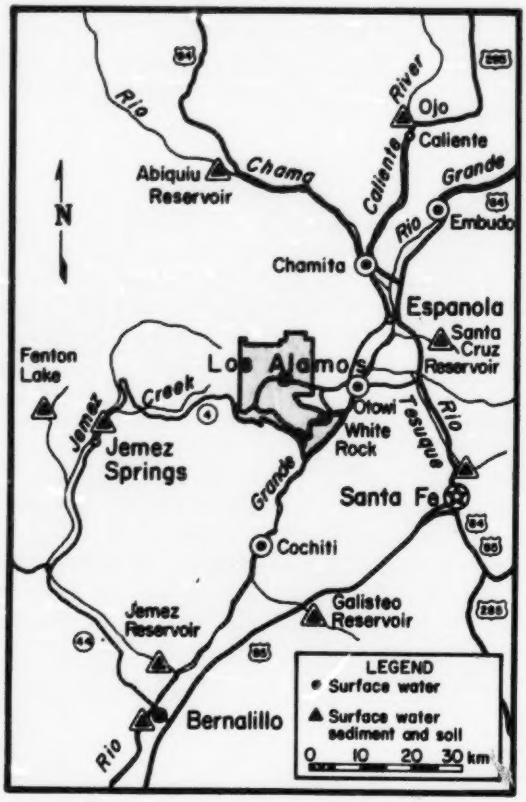
84
285
Rio
Chama
River
Ojo
Caliente
Caliente
Grande
Abiquiu
Reservoir
N
Rio
Embudo
84
Chamita
Espanola
Santa
Cruz
Reservoir
Fenton
Lake
Los Alamos
Creek
4
Otowi
Jemez
White
Rock
Tesuque
Rio
Jemez
Springs
Grande
Santa Fe
84
85
Cochiti
Jemez
Reservoir
Galisteo
Reservoir
285
44
85
LEGEND
● Surface water
▲ Surface water sediment and soil
0 10 20 30 km
Bernalillo
Rio

Figure 3. Locations of regional surface water, sediment, and soil sampling stations, Los Alamos

The range and average of constituents of water from these sampling stations are shown in table 9. The quality of this water fluctuates drastically due to variations in discharge and in size and terrain of the drainage area. Jemez Reservoir was dry when visited in early summer. In late fall, a sample of base flow was collected from the channel below the reservoir. The water was highly mineralized (dissolved solids 1430 μg/ml), as were both samples from Galisteo Reservoir (dissolved solids 158 μg/ml and 3030 μg/ml). The high mineral concentrations in these waters are due to the small dilution by runoff of the base flow which leaches minerals from the "red bed" terrain that constitutes most of the drainage area of these two streams. Traces of plutonium-238 were reported in water collected from the Caliente River in the spring and in both samples of water collected from Santa Cruz Reservoir collected in the spring and fall. Again, identification of plutonium-238 is tenuous at these low levels.

Table 9. Analysis of water from regional sampling stations, LASL
January-December 1972

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Gross alpha (pCi/liter)	33	11	<1.0	<2.0	1.0
Gross beta (pCi/liter)	33	17	<1.0	<5.0	1.0
Plutonium-238 (fCi/liter)	33	120	<50	<60	50
Plutonium-239 (fCi/liter)	33	<50	<50	<50	<50
Cesium-137 (pCi/liter)	33	<350	<350	<350	< 350
Tritium (nCi/liter)	33	12	<1.0	<2.0	1.0
Total uranium (ng/liter)	33	26 000	<200	<3 800	200

Surveillance water sampling

Samples of surface and ground water were collected and analyzed to help assess the overall impact of laboratory operations on the environment. Sampling locations are shown in figure 4.

The offsite monitoring consisted of collection of two water samples each from Los Alamos Spring and Basalt Spring, and one sample each from the stream in Frijoles Canyon and from Los Alamos Reservoir (table 10). The onsite monitoring consisted of collection of one sample of surface water each from Cañada del Buey, Pajarito Canyon, and Water Canyon (table 11). No results were abnormal for these stations (*2,3*).

Sediment monitoring program

Sediments are those earthen materials that have been transported and reworked by surface water. Samples were collected at the nine 35- to 50-km-distant stations from which regional surface water samples were obtained. In addition, samples were taken for surveillance from canyon stream beds in the vicinity of the laboratory at the stations shown in figure 3. Some of these sources are natural streams flowing either perennially or intermittently during the rainy season, and some are streams produced by effluents from laboratory or municipal facilities. Sediment samples from perennial streams were taken from dunes built up in eddies behind boulders in the main channel.

Table 10. Analyses of offsite surface and ground water, LASL, January-December 1972

Determination and units	Los Alamos Spring	Basalt Spring	Frijoles Canyon	Los Alamos Reservoir	Detection limit
Number of samples:	2	2	1	1	
Gross alpha (pCi/liter)	2.0	<1.0	<1.0	<1.0	1.0
Gross beta (pCi/liter)	4.0	4.0	1.0	<1.0	1.0
Plutonium-238 (fCi/liter)	<50	<50	<50	<50	50
Plutonium-239 (fCi/liter)	<50	<50	<50	<50	50
Cesium-137 (pCi/liter)	<350	<350	<350	<350	350
Tritium (nCi/liter)	<1.0	<1.0	<1.0	<1.0	1.0
Total uranium (ng/liter)	4600	3000	1300	1500	200

Table 11. Analyses of onsite surface water, LASL, January-December 1972

Sample determination and units	Canada del Buey	Pajarito Canyon	Water Canyon	Detection limit
Number of samples:	1	1	1	
Gross alpha (pCi/liter)	<1.0	<1.0	<1.0	1.0
Gross beta (pCi/liter)	2.0	3.0	3.0	1.0
Plutonium-238 (fCi/liter)	<50	<50	<50	50
Plutonium-239 (fCi/liter)	<50	<50	<50	50
Cesium-137 (pCi/liter)	<350	<350	<350	350
Tritium (nCi/liter)	1.0	3.0	<1.0	1.0
Total urnaium (ng/liter)	1800	3100	1300	200

From the intermittent streams, samples were collected across the main channel to a 2-cm depth and a 7.5-cm scoop. In still water, the samples were dredged from the bottom with a bailer at some convenient point. The samples were placed in a new polyethylene container for storage and transported to the laboratory. Samples were leached with acids, and determinations of gross alpha and beta activities, plutonium, cesium, and uranium were made on the acid leach.

Regional sediments

Sediments were collected and analyzed from the regional surface water sampling stations to provide general data on the quantities of radioactive material in the environment beyond the general laboratory area. Results of the analyses are given in table 12.

Surveillance sediment sampling

Locations of sediment sampling stations are shown in figure 4. Results of the analyses for onsite and offsite samples are given in table 13. In general, the results from this sampling program were consistent with previously reported values (*2,3*). Concentrations of plutonium lie in the range expected to result from worldwide fallout. One onsite sample exhibited a high uranium concentration, probably due to the fact that it was collected in an area where explosive tests could be expected to disperse uranium locally.

Soil monitoring program

Soils are those earthen materials that are weathered in place. They are sampled primarily to indicate the possibility of deposition of con-

Table,12. Analyses of regional sediment samples, LASL, January-December 1972

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Gross alpha (pCi/g)	7	3.1	<1.0	<1.4	1.0
Gross beta (pCi/g)	7	14	<3.0	8.0	3.0
Plutonium-238 (fCi/g)	9	9.0	<3.0	<4.1	3.0
Plutonium-239 (fCi/g)	9	25	<3.0	<6.6	3.0
Cesium-137 (pCi/g)	9	7.8	2.0	4.0	2.0
Total uranium (ng/g)	9	700	230	420	10

Table 13. Analyses of surveillance sediment samples, LASL, January-December 1972

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Offsite stations:					
Gross alpha (pCi/g)	4	2.5	<1.0	<1.4	1.0
Gross beta (pCi/g)	4	12	3.8	6.8	3.0
Plutonium-238 (fCi/g)	4	<3.0	<3.0	<3.0	3.0
Plutonium-239 (fCi/g)	4	26	<3.0	<8.8	3.0
Cesium-137 (pCi/g)	4	9.1	2.8	5.2	2.0
Total uranium (ng/g)	4	620	450	540	10
Onsite stations:					
Gross alpha (pCi/g)	3	2.6	<1.0	<1.5	1.0
Gross beta (pCi/g)	3	14	4.5	8.5	3.0
Plutonium-238 (fCi/g)	3	7.6	3.0	<4.5	3.0
Plutonium-239 (fCi/g)	3	4.1	<3.0	<3.6	3.0
Cesium-137 (pCi/g)	3	4.8	4.5	4.6	2.0
Total uranium (ng/g)	3	5200	90	1900	10

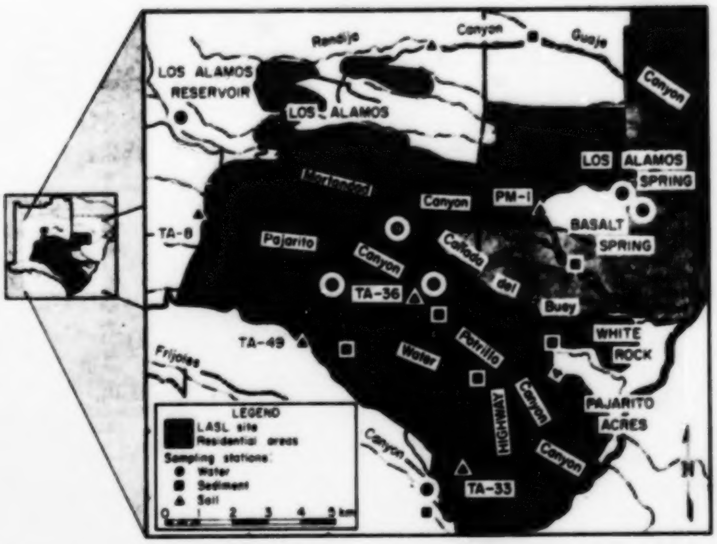
Rendija
Canyon
Guaje
Canyon
LOS ALAMOS RESERVOIR
LOS ALAMOS
LOS ALAMOS SPRING
Mortandad
Canyon
PM-1
BASALT SPRING
TA-8
Pajarito
Canyon
Cañada del
Buey
TA-36
TA-49
Water
Potrillo
Canyon
WHITE ROCK
Frijoles
HIGHWAY
PAJARITO ACRES
Canyon
TA-33
N
LEGEND
LASL site
Residential areas
Sampling stations:
● Water
■ Sediment
▲ Soil
0 1 2 3 4 5 km

Figure 4. Locations of surveillance water, sediment, and soil sampling stations, Los Alamos

taminants from the atmosphere. Samples are collected by taking five plugs, 7.5 cm in diameter and 5 cm deep, at the corners and center of a square that is 10 m on a side. The five plugs are combined into a single composite sample and analyzed for gross alpha and beta activities, plutonium, cesium, tritium, and uranium, using basically the same techniques as for sediment samples. Samples were taken at the regional surface water stations (figure 3) and at stations established for general surveillance in the vicinity of Los Alamos.

Regional soils

A summary of the results from the samples taken at distances of 35 to 50 km from the center of the laboratory area is given in table 14. The values are in line with those expected from natural radioactivity and from worldwide fallout from past weapons tests (*9*).

Surveillance soil sampling

A summary of the results from the samples taken in the vicinity of Los Alamos County is

Table 14. Analyses of regional soil samples, LASL, January-December 1972

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Gross alpha (pCi/g)	9	5.8	<1.0	<1.9	1.0
Gross beta (pCi/g)	9	18	6.2	9.7	3.0
Plutonium-238 (fCi/g)	9	10	<3.0	<4.4	3.0
Plutonium-239 (fCi/g)	9	14	4.0	8.8	3.0
Cesium-137 (pCi/g)	9	11	3.2	4.8	2.0
Tritium [a] (nCi/liter)	9	6.2	<3.0	<3.5	3.0
Total uranium (ng/g)	9	780	90	420	10

[a] Soil moisture distilled from sample.

Table 15. Analyses of surveillance soil samples, LASL, January-December 1972

Determination and units	Number of samples	Range			Detection limit
		Maximum	Minimum	Average	
Offsite stations:					
Gross alpha (pCi/g)	4	3.8	2.3	2.6	1.0
Gross beta (pCi/g)	4	17	4.7	12	3.0
Plutonium-238 (fCi/g)	4	<3.0	<3.0	<3.0	3.0
Plutonium-239 (fCi/g)	4	19	9.0	15	3.0
Cesium-137 (pCi/g)	4	8.4	5.9	7.2	2.0
Tritium [a] (nCi/liter)	4	5.7	<3.0	<4.0	3.0
Total uranium (ng/g)	4	970	150	380	10
Onsite stations:					
Gross alpha (pCi/g)	2	2.3	1.0	1.7	1.0
Gross beta (pCi/g)	2	12	<3.0	<7.5	3.0
Plutonium-238 (fCi/g)	2	<3.0	<3.0	<3.0	3.0
Plutonium-239 (fCi/g)	2	15	<3.0	<9.0	3.0
Cesium-137 (pCi/g)	2	7.1	4.3	5.7	2.0
Tritium [a] (nCi/liter)	2	<3.0	<3.0	<3.0	3.0
Total uranium (ng/g)	2	730	580	670	10

[a] Soil moisture distilled from sample.

given in table 15. Again, the values found are in general agreement with those expected from natural activity and worldwide fallout.

Discussion

The results of the monitoring program for this report period confirm the generally low radiation levels in the Los Alamos environs noted in previous periods. Measurements of the gross activities in air and precipitation indicate concentrations similar to those measured at other locations in the northern hemisphere where activity is entirely attributable to the presence of worldwide fallout. Airborne plutonium and tritium measurements reveal that laboratory activities have elevated slightly the levels of both materials above the concentrations expected from fallout due to past weapons testing and reentry and burnup of isotope power sources contained in space vehicles.

In the text, comparisons were made between observed concentrations and applicable guides for offsite and onsite areas, respectively. Since site boundaries are near some of the onsite stations used for these comparisons and since public use of adjacent roads is normally permitted (although use can indeed be restricted), comparisons are made in this section between onsite concentrations and offsite guides.

The highest average of total plutonium (plutonium-238 + plutonium-239) concentration at a station accessible to the public was 140 aCi/m^3 and occurred at Station 34, TA–3. (Station 33 recorded a slightly higher average total concentration, but is located in a remote area inaccessible to the public.) This combined onsite concentration is approximately 0.23 percent of the most restrictive guide value of 60 fCi/m^3 for the soluble form of plutonium-239 in uncontrolled areas.

During this reporting period, the highest average onsite tritiated moisture concentration in the Los Alamos area was 180 pCi/m^3, less than 0.1 percent of the guide value of 0.2 μCi/m^3 for uncontrolled areas. This concentration was sufficient to produce a whole-body dose of about 0.3 mrem, using the quality factor of 1.7 used in the derivation of the 1960 ICRP-NCRP maximum permissible concentration that apparently served as the basis for the AEC Manual Chapter 0524 concentration guides. If the quality factor of 1.0 now accepted by the ICRP and NCRP is used for these low-energy beta radiations, this dose is about 0.2 mrem. This may be compared with the radiation protection guide for annual dose to the whole body (AEC Manual Chapter 0524) of 500 mrem for an individual or 170 mrem for the most restrictive segment of the population.

External gamma- and x-radiation levels, as measured by the TLD array were comparable to those measured elsewhere at approximately the same elevation. This suggests that the predominant contribution to external dose is from cosmic and naturally occurring terrestrial sources.

The Los Alamos water supply remained uninfluenced by laboratory operations. Traces of plutonium were tenuously identified in water samples from two offsite bodies of surface water.

Small quantities of plutonium and some beta emitters, both a result of past disposal operations, were found in sediment collected in an offsite canyon. This area, although accessible to the public, is reasonably isolated, so that occupancy is limited to an occasional hiker or hunter. This low occupancy factor and/or the association of the material with large quantities of sediment would preclude the uptake of any significant quantities by people, animals, or plants.

Previous coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1971	November 1973

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2. Mound Laboratory[1]
January–December 1972

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 0.73 km^2 of land in Miamisburg, Ohio, about 19 km southwest of Dayton. The area within a 32 km radius of the laboratory includes essentially all of Montgomery County and approximately 30 to 60 percent of the adjoining counties of Butler, Greene, Preble and Warren. The predominant geographical feature in the five-county region is the Great Miami River which flows through Miamisburg from the northeast to the southwest. This river valley area is generally highly industrialized. The remainder of the region is predominantly agricultural with some light industry and scattered residential communities. The primary agricultural activity in the area is raising field crops such as corn and soybeans. Approximately 10 percent of the land area in agricultural use is devoted to pasturing livestock (*1*).

Weather conditions in the area are considered moderate. The average annual precipitation is approximately 91 cm and is evenly distributed throughout the year. Winds predominate out of the south and west except during the summer months when a higher frequency is observed out of the southwest. The wind speed averages about 16 km per hour annually (*2*).

Mound Laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; research, development, and production of explosive materials; separation, purification, and sale of stable isotopes of the noble gases; and development, design, and fabrication of radioisotopic heat sources for medical application and space exploration. Radionuclides currently being worked with include plutonium-238, polonium-210 and tritium.

Interest in the health and safety of employees and the public is manifested by an Environmental Control Program which has been in existence continuously during the laboratory's history. Fundamental objectives of the environmental control program are the containment of radioactive waste and control of nonradioactive effluents to levels well within existing or proposed standards. As part of the program's control function, all effluents containing polluting materials are controlled at each operating step. As a result of this control, any release of low-level gaseous and liquid wastes to the environment are carefully controlled and dispersed to ensure that concentrations are well within recommended standards.

Air monitoring

Mound Laboratory, through the AEC, has entered into a contractual agreement with the Montgomery County Combined General Health District (MCCGHD) for the installation and operation of a sampling network consisting initially of 10 offsite air sampling stations. Installation of the sampling stations was completed during February 1972. The sampling sites were located on the basis of a diffusion model (*3*) developed by the Dayton Laboratory of Monsanto Research Corporation. Five of the samplers are located within a 1.6 km radius of the laboratory perimeter. The remaining five samplers are located in adjacent population centers in the northeastern quadrant up to 16 km from the laboratory. The sampling sites are shown in figure 5. Eleven additional sampling stations will be completed during the first quarter of 1973. Two types of samples are collected: a particulate sample for plutonium-238 and polonium-210 analysis, and a gas bubbler sample for tritium oxide analysis.

The particulate sample is collected on a 200-mm-diameter Microsorban disk by means of a continuously operating high-volume air sampler. The air is sampled at the rate of 1 m^3/min. The Microsorban disk is changed weekly, which represents a sample of approximately 10 000 m^3 of air. Polonium-210 analyses are performed on a weekly basis while the plutonium-238 analyses are performed on a monthly composite sample. The plutonium-238 analysis

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[1] Summarized from "Environmental Monitoring Report, 1972, Mound Laboratory."

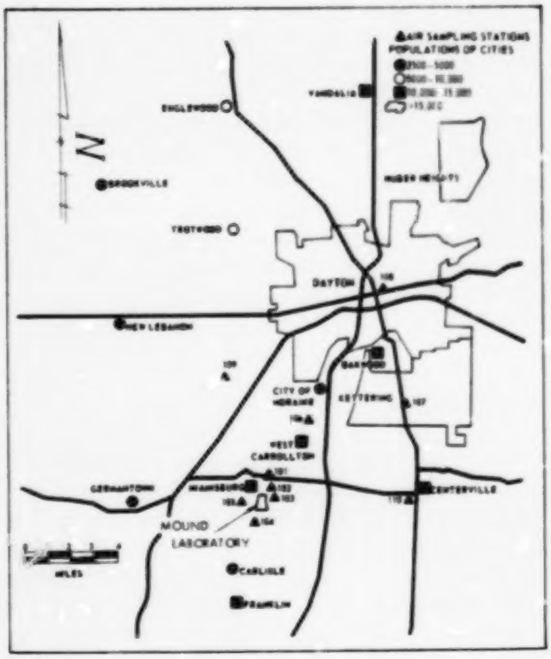


Figure 5. Offsite air sampling zones, Mound Laboratory

includes the use of plutonium-236 as an internal standard in conjunction with alpha pulse height analysis which allows correction for chemical and counting losses to be made. The results reported below represent total concentrations of the analyzed radionuclides including contributions from natural sources and atmospheric fallout.

Since commercial sales of polonium-210 from Mound Laboratory have ceased, and the concentration of polonium-210 measured in the atmosphere has significantly decreased, samples collected at only two offsite locations were analyzed for polonium-210 during 1972. If a significant increase in the concentration of polonium-210 is observed at these locations, additional analyses at other locations will be performed to assure that control of emissions is still effective (i.e., well within stringent AEC standards). The results of the polonium-210 analyses are summarized in table 16. Average concentrations measured were only 0.02 percent of the AEC standard.

Table 16. Atmospheric monitoring for polonium-210, Mound Laboratory, January-December 1972

Location	Number of samples	Range (fCi/m³)	Average concentration[a] (fCi/m³)	Percent of AEC standard[b]
Onsite:				
211	26	0.93-3.7	2.3±0.1	0.01
212	26	.70-2.4	1.3± .1	.006
213	26	.66-2.6	1.2± .1	.006
214	26	.74-4.5	1.3± .1	.007
215	26	.59-2.3	1.2± .1	.006
Offsite:				
101	46	.52-3.7	1.3± .1	.02
108	42	.6 -2.9	1.3± .1	.02

[a] Minimum detection limit (MDL) for polonium-210 in air is 0.02 fCi/m³.
[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³ for onsite locations and 7 pCi/m³ for offsite locations.

The average plutonium-238 concentrations were all less than 0.3 percent of the AEC standards. The AEC standards used for comparison is the guide for the soluble form of the isotope and for the general population. This is the most restrictive AEC standard for plutonium-238 and is applied since the solubility of the measured particles in the potential receptor (i.e., the human body) is unknown at this time. These results are summarized in table 17.

Table 17. Atmospheric monitoring for plutonium-238, Mound Laboratory, January-December 1972

Location	Number of samples	Range (aCi/m³)	Average concentration[a] (aCi/m³)	Percent of AEC standard[b]
Onsite:				
211	26	10 - 929	400 ±10	0.6
212	26	10 - 129	58 ± 4	.08
213	26	8 -1 101	400 ±10	.6
214	26	39 - 153	140 ± 6	.2
215	26	18 - 33	22 ± 2	.03
Offsite:				
101	46	11 - 95	34 ± 3	.2
102	[c] 3		69 ± 5	.3
103	44	4.7- 188	56 ± 4	.3
104	45	5.7- 51	20 ± 2	.1
105	45	3.8- 27	9.6± 1	.05
106	45	2.7- 78	13 ± 2	.07
107	25	2.2- 11	4.9± 1.3	.02
108	43	3.2- 14	7.7± 1.5	.04
109	41	2.4- 9.2	5.0± 1.3	.02
110	27	3.5- 7.3	5.1± 1.3	.03

[a] Minimum detection limit (MDL) for plutonium-238 in air is 0.5 aCi/m³.
[b] The applicable AEC radiation standard for plutonium-238 in air is 70 fCi/m³ for onsite locations and 20 fCi/m³ for offsite locations.
[c] Combined to form a single, composite sample.

The gas bubbler sample is also collected on a continuous basis at approximately 3000 cm³/min. The sample is collected by bubbling air through 500 ml of a water-ethylene glycol mixture. Any tritium oxide present in the air is collected in the solution. The ethylene is added to the water to lower both its vapor pressure and freezing point. The sampling and analysis are directed to tritium oxide rather than elemental tritium since the AEC standard for the oxide is 200 times more restrictive. A sample representing 30 m^3 of air is collected and an aliquot of this is counted in a liquid scintillation spectrometer. The average concentrations of tritium oxide measured during 1972 were all less than approximately 0.1 percent of the AEC standard. These results are summarized in table 18.

Table 18. Atmospheric monitoring for tritium oxide, Mound Laboratory, January-December 1972

Location	Number of samples	Range (pCi/m^3)	Average concentration [a] (pCi/m^3)	Percent of AEC standard [b]
Onsite:				
211	26	<3– 290	77 ± 7	0.04
212	26	<3–2 200	200 ±10	.1
213	26	<3–1 250	110 ± 8	.05
214	26	<3– 690	82 ± 7	.04
215	26	<3– 430	51 ± 6	.03
Offsite:				
101	46	<3– 580	101 ± 6	.1
102	37	<3– 250	61 ± 5	.09
103	45	<3–1 640	81 ± 6	.1
104	42	<3– 270	30 ± 4	.04
105	45	<3– 110	12 ± 2	.02
106	45	<3– 59	7.5 ± 1.6	.01
107	43	<3– 25	3.6 ± 1.1	.005
108	44	<3– 16	3.2 ± 1.1	.005
109	45	<3– 21	4.1 ± 1.1	.006
110	43	<3– 79	4.9 ± 1.2	.007

[a] Minimum detection limit (MDL) for tritium oxide in air is 3 pCi/m^3.

[b] The applicable AEC radiation standard for tritium in air is 200 nCi/m^3 for onsite locations and 70 nCi/m^3 for offsite locations.

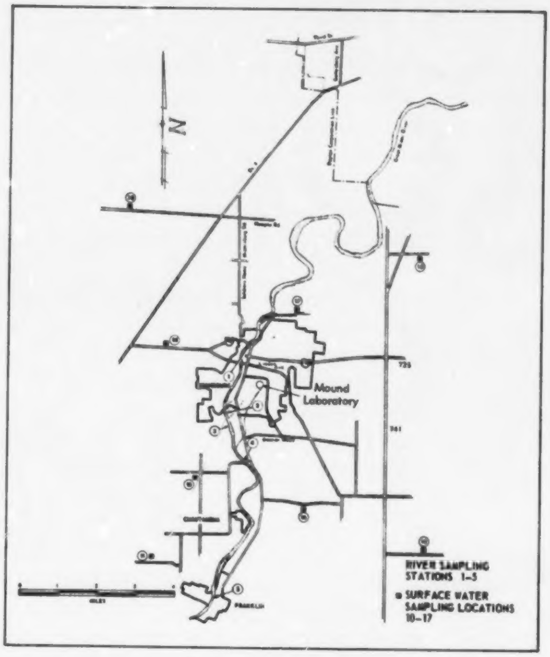
An onsite perimeter network of five continuous, high-volume air samplers became operational during July 1972. This network replaced three interim samplers in operation since 1970. Particulate and gas samples are collected by the onsite samplers at the same flow rate as the offsite samplers (i.e., 1 m^3/min and 3000 cm^3/min, respectively).

The samples are also analyzed in the same manner as the offsite samples with the exception that all onsite samples are analyzed for polonium-210. The results of the onsite polonium-210 analyses are summarized in table 16. The average concentrations of polonium-210, measured during 1972 at the onsite sampling stations, were all less than 0.01 percent of the AEC standard. The AEC standard used for comparison for these onsite samples as well as plutonium and tritium oxide samples is the guide for an uncontrolled area.

The average plutonium-238 concentrations measured onsite were all less than 0.6 percent of the AEC standard and are summarized in table 17. The results of the onsite tritium oxide analyses are summarized in table 18. The average concentrations measured were all less than 0.1 percent of the AEC standard.

Water monitoring

Water sampling locations along the bank of the Great Miami River were revised during the first half of 1972. The revised locations will provide samples which are more representative of river water after proper mixing of Mound's effluent has occurred. Guidelines proposed by the federal EPA were utilized in selecting the new sampling locations. These locations are shown in figure 6. Water samples are collected at these locations daily and are subjected to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RIVER SAMPLING STATIONS 1–5
SURFACE WATER SAMPLING LOCATIONS 10–17

Figure 6. Offsite water monitoring stations, Mound Laboratory

specific analyses for polonium-210, plutonium-238 and tritium oxide. The concentrations of polonium-210 measured in the Great Miami River are summarized in table 19. The average concentrations were all less than 0.3 percent of the AEC standard.

Table 19. Polonium-210 concentrations in the Great Miami River, Mound Laboratory, January-December 1972

Location	Number of samples	Range (pCi/liter)	Average concentration [a] (pCi/liter)	Percent of AEC standard [b]
1	165	<0.13–1.5	0.44 ±0.37	0.2
2	165	<.13–1.6	.41 ± .36	.2
3	165	<.13–1.7	.59 ± .38	.3
4	165	<.13–1.1	.37 ± .34	.2
5	165	<.13–2.2	.40 ± .35	.2

[a] Minimum detection limit (MDL) for polonium-210 in water is 0.13 pCi/liter.

[b] The applicable AEC radiation protection standard for polonium-210 is 200 pCi/liter.

The concentrations of plutonium-238 measured in the Great Miami River are summarized in table 20. The average concentrations were less than 0.1 percent of the AEC standard.

The average concentrations of tritium oxide measured in the Great Miami River were all less than 0.5 percent of the AEC standard. These results are summarized in table 21.

Table 20. Plutonium-238 concentrations in the Great Miami River, Mound Laboratory, January-December 1972

Location	Number of samples	Range (pCi/liter)	Average concentration [a] (pCi/liter)	Percent of AEC standard [b]
1	165	0.1–16	1.0 ±0.1	0.05
2	165	.3– 8.0	.6 ± .09	.03
3	165	.2– 6.5	2.2 ± .2	.1
4	165	.1– 8.7	2.0 ± .2	.1
5	165	.1–27	2.3 ± .2	.1

[a] Minimum detection limit (MDL) for plutonium-238 in water is 0.003 pCi/liter.

[b] The applicable AEC radiation protection standard for plutonium-238 in water is 2 000 pCi/liter.

Table 21. Tritium concentrations in the Great Miami River, Mound Laboratory, January-December 1972

Location	Number of samples	Range (nCi/liter)	Average concentration [a] (nCi/liter)	Percent of AEC standard [b]
1	165	<0.3– 2.5	0.8 ±0.3	0.08
2	165	<.3–105	4.8 ± .5	.5
3	165	<.3– 15	2.2 ± .4	.2
4	165	<.3– 8.2	1.1 ± .4	.1
5	165	<.3– 1.9	.9 ± .4	.09

[a] Minimum detection limit (MDL) for tritium in water is 0.3 nCi/liter.

[b] The applicable AEC radiation protection standard for tritium in water is 1 000 nCi/liter.

Eight additional surface water locations such as ponds and streams are sampled quarterly. These locations are shown in figure 6. A sample of approximately 4 liters is collected at each location and analyzed for plutonium-238, polonium-210, and tritium oxide. The average concentrations of polonium-210 measured at the surface water locations during 1972 were less than 0.1 percent of the AEC standard. The average concentrations of plutonium-238 measured at these locations during 1972 were less than 0.03 percent of the AEC standard. The average concentrations of tritium oxide measured at these locations were less than 0.6 percent of the AEC standard. The results of the surface water monitoring program are summarized in tables 22, 23, and 24.

Drinking water from communities in the surrounding area is sampled quarterly and analyzed for tritium oxide. The concentrations of tritium oxide were found to be less than 1.3 percent of the AEC standard. The results of the community drinking water sampling program are summarized in table 25.

Table 22. Summary of surface water monitoring for polonium-210, Mound Laboratory, January-December 1972

Location	Number of samples	Range (pCi/liter)	Average concentration [a] (pCi/liter)	Percent of AEC standard [b]
10	3	0.05–.45	0.27 ±0.17	0.1
11	3	.15–.27	.20 ± .15	.1
12	3	<.03–.27	.16 ± .15	.08
13	3	<.03–.45	.18 ± .15	.09
14	3	<.03–.32	.16 ± .15	.08
15	3	<.03–.14	.09 ± .14	.05
16	3	.09–.31	.22 ± .16	.1
17	3	<.03–.32	.13 ± .15	.07

[a] Minimum detection limit (MDL) for polonium-210 in water is 0.03 pCi/liter.

[b] The applicable AEC radiation protection standard for polonium-210 in water is 200 pCi/liter.

Table 23. Summary of surface water monitoring for plutonium-238, Mound Laboratory, January-December 1972

Location	Number of samples	Range (pCi/liter)	Average concentration [a] (pCi/liter)	Percent of AEC standard [b]
10	2	0.07–0.11	0.09 ±0.01	0.005
11	2	.02– .05	.04 ± .003	.002
12	2	.07– .09	.08 ± .004	.004
13	2	.05– .15	.10 ± .01	.005
14	2	.07– .15	.11 ± .01	.005
15	2	.07– .10	.09 ± .01	.005
16	2	.07– .17	.10 ± .01	.005
17	2	.27– .78	.53 ± .04	.026

[a] Minimum detection limit (MDL) for plutonium-238 is 0.04 pCi/liter.

[b] The applicable AEC radiation protection standard for plutonium-238 in water is 2 000 pCi/liter.

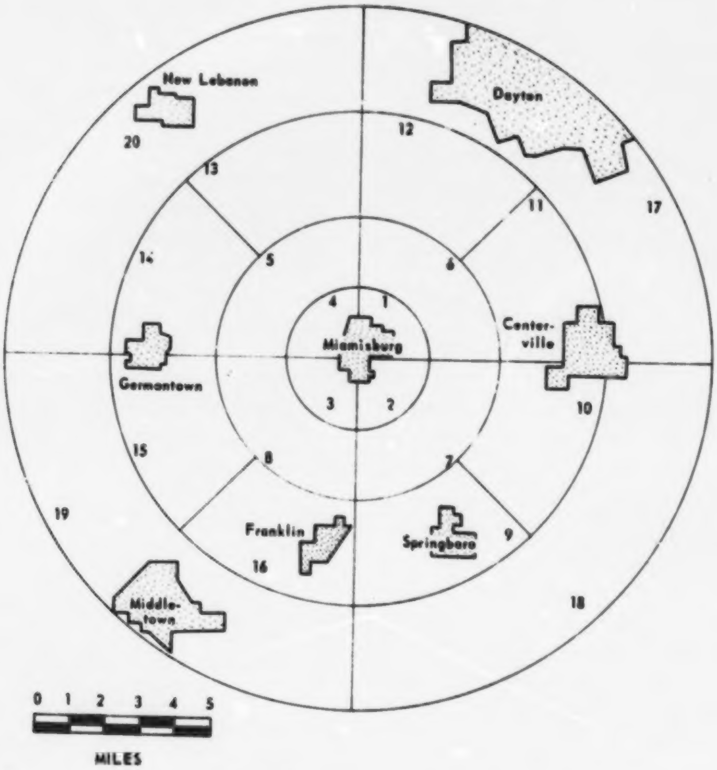
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Figure 7. Soil sampling sectors, Mound Laboratory

Table 24. Summary of surface water monitoring for tritium, Mound Laboratory, January-December 1972

Location	Number of samples	Range (nCi/liter)	Average concentration [a] (nCi/liter)	Percent of AEC standard [b]
10	4	<0.3-1.4	0.7 ±0.2	0.07
11	4	<.3-1.0	.6 ± .2	.06
12	4	<.3-1.5	.5 ± .2	.05
13	4	<.3- .5	.3 ± .2	.03
14	4	3.1-9.3	6.0 ± .2	.60
15	4	1.8-4.4	3.5 ± .2	.35
16	4	.4-2.8	1.3 ± .2	.13
17	4	3.7-6.2	4.7 ± .2	.47

[a] Minimum detection limit (MDL) for tritium in water is 0.3 nCi/liter.

[b] The applicable AEC radiation protection standard for tritium oxide in water is 1 000 nCi/liter.

Food and vegetation

Various locally grown foodstuffs and vegetation samples are collected from the surrounding area. Where possible, sampling sites are chosen at maximum deposition locations predicted on the basis of the diffusion model previously mentioned. The samples collected include milk, fruits, vegetables, grass, field crops and aquatic life. The intent of this portion of the Environmental Monitoring Program is to determine if there is any uptake and concentration of radionuclides by plant or animal

Table 25. Summary of community drinking water tritium oxide levels, Mound Laboratory, January-December 1972

Location	Number of samples	Range (nCi/liter)	Average concentration [a] (nCi/liter)	Percent of AEC standard [b]
Bellbrook	4	<0.3– 0.8	0.4±0.2	0.04
Carlisle	1	------------	1.4± .2	.14
Centerville	2	.4– .5	.4± .2	.04
Dayton	4	<.3– .5	.3± .2	.03
Eaton	1	------------	<.3± .2	<.03
Franklin	3	.3– 1.6	1.0± .2	.10
Germantown	1	------------	1.1± .2	.11
Miamisburg	5	10 –17	12.5± .2	1.25
Middletown	1	------------	.3± .2	.03
Moraine	1	------------	.3± .2	.03
Springboro	3	<.3	<.3± .2	<.03
Tipp City	1	------------	<.3± .2	<.03
Waynesville	2	<.3– .5	.4± .2	.04
West Carrollton	1	------------	.4± .2	.04
West Milton	1	------------	<.3± .2	<.03

[a] Minimum detection limit (MDL) for tritium oxide is 0.3 nCi/liter.

[b] The applicable AEC radiation protection standard for tritium oxide in water is 1 000 nCi/liter.

Table 26. Summary of foodstuffs and vegetation analysis, Mound Laboratory January-December 1972

Type of sample	Number of samples	Plutonium-238 (fCi/g wet weight) [a]		Percent of AEC standard [b]	Tritium (pCi/g wet weight) [c]		Percent of AEC standard [d]
		Range	Average concentration [a]		Range	Average concentration [c]	
Milk	7	0.09–4.6	1.4±0.07	0.07	<0.1	<0.1	<0.01
Fruits and vegetables	6	1.7 –2.1	2.0± .2	.1	2.2– 2.3	2.3±0.1	.23
Grass	8	.5 –2.0	1.1± .1	.05	28 –103	49 ± .2	4.9
Field crops	2	.57– .64	.6± .1	.03	<.1– 16	8.2± .2	.8
Aquatic life	1	------------	6.0± .6	.3	<.1	<.1	<.01

[a] Minimum detection limit (MDL) for plutonium-238 in foodstuffs is 0.015 fCi/g.

[b] The applicable AEC radiation protection standard for plutonium-238 is 2 pCi/g.

[c] Minimum detection limit for tritium in foodstuffs is 0.1 pCi/g.

[d] The applicable AEC radiation protection standard for tritium oxide is 1 000 pCi/g.

life. As mentioned previously, commercial sales of polonium-210 from Mound Laboratory have ceased and, since air and water are monitored for polonium-210, foodstuff samples are not analyzed for polonium-210. The plutonium-238 content of the foodstuff and vegetation samples is determined by slowly evaporating the samples to dryness and then proceeding with the same techniques used for plutonium-238 analyses of air samples. Milk samples are analyzed for tritium oxide by distilling the water fraction from an aliquot of the entire sample. The distillate is then analyzed for tritium by liquid scintillation spectrometry in the same manner as the water samples previously discussed in this report. The remaining food samples are analyzed for tritium by oxidizing the samples in a controlled air stream and collecting the combustion products.

The tritium content of the combustion products is then determined by liquid scintillation spectrometry as discussed above. This technique allows analysis for total tritium in the samples rather than tritium oxide. The results of the food and vegetation analyses are summarized in table 26. The concentration is given in terms of the sample weight before evaporation to dryness. The vegetables analyzed included cucumbers, turnips, onions, and tomatoes. The sample of aquatic life analyzed included only the edible fleshy portions from six small bluegills. The concentration of tritium measured in grass samples appears to be measurably above background concentrations, but still well within the AEC standards. These results are the first utilizing the total tritium technique at Mound Laboratory. More data must be accumulated before any conclusion can be reached. No

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other indication has been found that there is any significant uptake and concentration by plant or animal life of these radionuclides handled at Mound Laboratory.

Soil and silt

The soil sampling program has included two aspects of soil monitoring. One aspect, which was reported in MLM–1922 *Environmental Monitoring Report, July–December 1971 and 1971 Summary,* is the evaluation of the resuspendable amounts of plutonium-238 in soil. For this evaluation surface scrapings, approximately 3 mm deep, of undisturbed soil are collected and analyzed. Review of data reported in 1971 revealed that evaluation of resuspendable plutonium in soil is best accomplished by the network of continuous high-volume air samplers. Therefore, surface soil sampling was suspended during 1972. If air sampling results indicate a potential problem in this area, surface soil sampling will be resumed. The second aspect of soil monitoring is the documentation for historical purposes of the total accumulation and distribution of plutonium deposited offsite, and for verification of Mound Laboratory's atmospheric diffusion model. Present plans are to repeat and refine the total inventory at 5-year intervals once the initial inventory is completed.

Soil core samples 9 cm in diameter, approximately 30 cm deep, are taken for the inventory determination. Core samples were collected at two locations in each quadrant around the laboratory during 1972. Five cores were collected from a square area 9 meters on a site at each location and composited to form one core sample. Additional core samples for background control data were taken from locations greater than 80 km from the laboratory.

Soil samples are digested with an acid mixture to extract the plutonium. The solution is then passed over an ion exchange column specific for plutonium and analyzed in the same manner as the particulate air samples previously discussed in this report. This leach method has been compared with a fusion method for soil analysis (*4*). Good agreement was obtained between the two methods of analysis. The leach method was chosen for the soil analysis because larger samples, which minimize sampling and aliquoting errors and increase sensitivity, can be handled with this method. The results of the core sampling program are summarized in table 27. As mentioned previously in this report, no standards have been established for radioactive species in soil. Additional sample analyses are necessary before a total inventory can be calculated, and these are continuing as part of Mound Laboratory's comprehensive environmental control program.

Table 27. Plutonium-238 results in soil core samples, Mound Laboratory, January-December 1972

Location		Plutonium-238 • (nCi/m²)
Direction	Distance (km)	
North:	1.4	18 ±2
	4.2	1.7 ± .2
East:	.8	94 ±9
	1.9	8.9 ± .9
South:	1.0	3.0 ± .3
	2.3	3.7 ± .4
West:	.8	9.0 ± .9
	2.1	2.3 ± .2
Background		.05 ± .005

• Minimum detection limit for plutonium-238 in soil is 0.004 nCi/m².

Silt samples are collected quarterly from four locations on the Great Miami River. These samples are taken at four of the same locations that water samples are taken from and are identified by the same numbers shown in figure 7. Additional silt samples are collected annually from the same surface water locations which are sampled monthly. The silt samples are analyzed in the same manner as the soil samples. The results of Great Miami River silt sampling for 1972 are summarized in table 28.

Table 28. Summary of Great Miami River silt samples for plutonium-238, Mound Laboratory, January-December 1972

Location	Number of samples	Range (fCi/g)	Average concentration • (fCi/g)
1	3	50–190	121 ± 3
2	3	60–3500	1330 ± 10
3	4	40–130	94.4 ± 3
4	4	200–1700	531 ± 6
5	2	290–1350	821 ± 8

• Minimum detection limit for plutonium-238 in silt samples is 0.5 fCi/g. The concentration is in terms of standard dry weight.

The results of the silt sampling from the area ponds are summarized in table 29. There ap-

Table 29. Concentrations of plutonium-238 in pond silt, Mound Laboratory, January-December 1972

Location	Plutonium-238 • (fCi/g)
10	10.9±0.9
11	6.1± .7
12	13.0±1.0
13	3.1± .5
14	8.5± .8
15	7.6± .8
16	11.8±1.0
17	58.2±2.1

• Minimum detection limit for plutonium-238 in silt samples is 0.5 fCi/g The concentration is in terms of standard dry weight.

pears to be a very slight accumulation of plutonium-238 in river silt from the very small amounts of plutonium-238 which are discharged to the river. However, as mentioned previously, there does not appear to be any reentrainment of plutonium-238 by plant or animal life in the river nor by the river itself. No significant accumulation is indicated, however, by the pond silt data. As previously mentioned in this report, there are no standards for radioactive species in soil or silt.

Summary

The average concentrations of polonium-210, plutonium-238, and tritium detected in the environment surrounding Mound Laboratory, Miamisburg, Ohio, are presented for calendar year 1972. The average concentrations of these radioisotopes were well within the stringent standards adopted by the Atomic Energy Commission.

Atmospheric monitoring for radioactive species was upgraded by the completion of an offsite network of 10 continuous, high-volume air sampling stations during February 1972. Prior to that time, a routine offsite grab sampling program had been in effect since laboratory operations began in 1949. An additional 11 air sampling stations are scheduled for completion by the first quarter of 1973. The average concentrations of polonium-210, plutonium-238, and tritium measured in air during this period were less than 0.02 percent, 0.3 percent, and 0.1 percent of their respective AEC standards. A comparison to results obtained from grab sampling during 1971 is not warranted since the offsite network in 1972 utilized continuous sampling rather than grab sampling.

Water monitoring for radioactive species found the average concentrations of polonium-210, plutonium-238, and tritium measured at the water sampling locations during this period to be less than 0.3 percent, 0.1 percent, and 0.5 percent of their respective AEC standards. These results represent a significant reduction in concentrations of polonium-210 and tritium over those measured during 1971.

Additionally, data concerning radioactive species in surface water, community drinking water, foodstuffs, soil and silt are presented. No significant uptake of radioactive species from air or water by plant or animal life has been observed. No reentrainment of radioactive species from soil or silt is indicated at this time. Soil core sample analyses will continue to establish a plutonium-238 soil inventory as part of the total program to assess the impact of the laboratory's operations on the environment.

These data reflect the effectiveness of Mound's Environmental Control Program and indicate that the operation of the laboratory has negligible effect on the environment.

Previous coverage in Radiation Data and Reports:

Period	Issue
January–December 1971	March 1974

REFERENCES

(*1*) STATE OF OHIO. Statistical abstract of Ohio—1969. State of Ohio Economic Research Division (March 1969) p. 6.

(*2*) U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE; CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE and NATIONAL AIR POLLUTION CONTROL ADMINISTRATION. Report for consultation on the metropolitan Dayton intrastate air quality control region (September 1969) p. 11.

(*3*) EIMUTIS, E. C., R. P. QUILL and W. H. WESTENDORF. Development of an atmospheric diffusion model for optimum location of sampling sites in the Mound Laboratory environment, Final Report Phase I. Monsanto Research Corporation, Dayton Laboratory, Dayton, Ohio (June 25, 1971) p. 31.

(*4*) BISHOP, C. T., W. E. SHEEHAN, R. K. GILLETTE and B. ROBINSON. Comparison of a leaching method and a fusion method for the determination of plutonium-238 in soil. Presented at Distribution and Measurement of Plutonium in the Environment, Los Alamos Scientific Laboratory, Los Alamos, New Mex. (August 4–5, 1971).

Nuclear Power Reactors in the United States
September 30, 1974

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

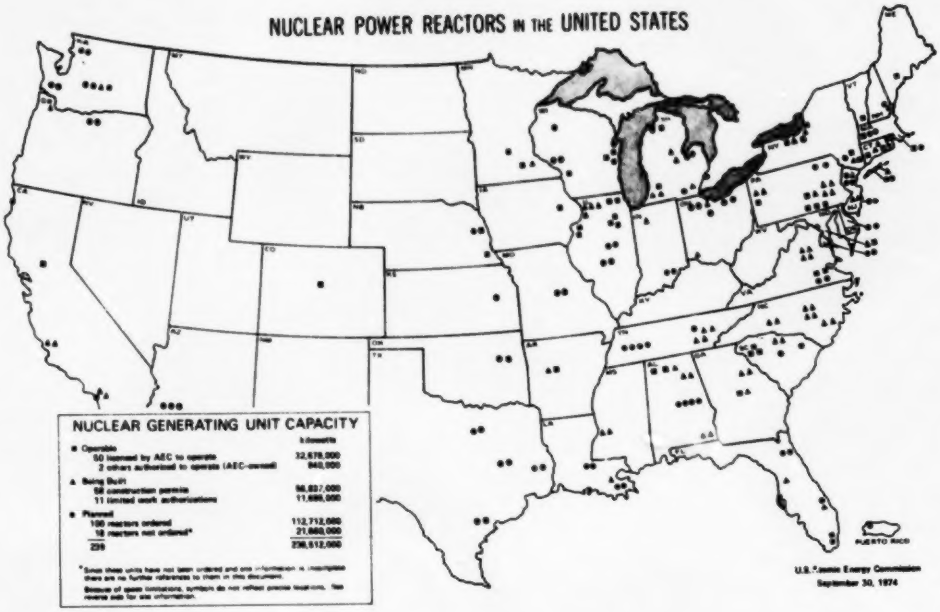
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR GENERATING UNIT CAPACITY
kilowatts
● Operable
50 licensed by AEC to operate 32,678,000
2 others authorized to operate (AEC-owned) 840,000
▲ Being Built
58 construction permits 56,837,000
11 limited work authorizations 11,885,000
● Planned
100 reactors ordered 112,712,000
18 reactors not ordered* 21,660,000
239 236,612,000
*Since these units have not been ordered and site information is incomplete there are no further references to them in this document.
Because of space limitations, symbols do not reflect precise locations. See reverse side for site information.
PUERTO RICO
U.S. Atomic Energy Commission
September 30, 1974

Figure 1. Nuclear power reactors in the United States, September 30, 1974

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1976
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Clanton	Alan R. Barton Nuclear Plant: Unit 1	1,159,000	Alabama Power Co.	1984
Clanton	Alan R. Barton Nuclear Plant: Unit 2	1,159,000	Alabama Power Co.	1985
Clanton	Alan R. Barton Nuclear Plant: Unit 3	1,159,000	Alabama Power Co.	1986
Clanton	Alan R. Barton Nuclear Plant: Unit 4	1,159,000	Alabama Power Co.	1987
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,213,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,213,000	Tennessee Valley Authority	1980
ARIZONA				
Wintersburg	Palo Verde Nuclear Generation Station: Unit 1	1,270,000	Arizona Public Service	1981
Wintersburg	Palo Verde Nuclear Generating Station: Unit 2	1,270,000	Arizona Public Service	1982
Wintersburg	Palo Verde Nuclear Generating Station: Unit 3	1,270,000	Arizona Public Service	1984
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1974
Russellville	Arkansas Nuclear One: Unit 2	912,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Eureka	Humboldt Bay Power Plant: Unit 3	65,000	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1980
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,084,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,106,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	913,000	Sacramento Municipal Utility District	1975
*	–	1,128,000	Pacific Gas & Electric Co.	1981
*	–	1,128,000	Pacific Gas & Electric Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1974
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Nuclear Energy Co.	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Nuclear Energy Co.	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,156,000	Northeast Nuclear Energy Co.	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1981
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1984
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1974
Ft. Pierce	St. Lucie Plant: Unit 1	810,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	810,000	Florida Power & Light Co.	1979
*	–	1,300,000	Florida Power Corp.	–
*	–	1,300,000	Florida Power Corp.	–
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,113,000	Georgia Power Co.	–
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,113,000	Georgia Power Co.	–
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1978
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1979
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1980
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1981
Braidwood	Braidwood: Unit 1	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,120,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant: Unit 1	955,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	955,000	Illinois Power Co.	1982
INDIANA				
Westchester	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1979
Madison	Marble Hill Nuclear Power Station: Unit 1	1,150,000	Public Service Indiana	1983
Madison	Marble Hill Nuclear Power Station: Unit 2	1,150,000	Public Service Indiana	1984
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	569,000	Iowa Electric Light and Power Co.	1974
*		1,000,000	Iowa Electric Light and Power Co.	1983
KANSAS				
Burlington	Wolf Creek Generation Station: Unit 1	1,150,000	Kansas Gas & Electric–Kansas City P & L	1982
LOUISIANA				
Taft	Waterford Generating Station: Unit 3	1,113,000	Louisiana Power & Light Co.	1980
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1981
Alliance	St. Rosalie Generating Station: Unit 1	1,160,000	Louisiana Power & Light Co.	1982
Alliance	St. Rosalie Generating Station: Unit 2	1,160,000	Louisiana Power & Light Co.	1984
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972

Figure 1. Nuclear power reactors in the United States, September 30, 1974—continued

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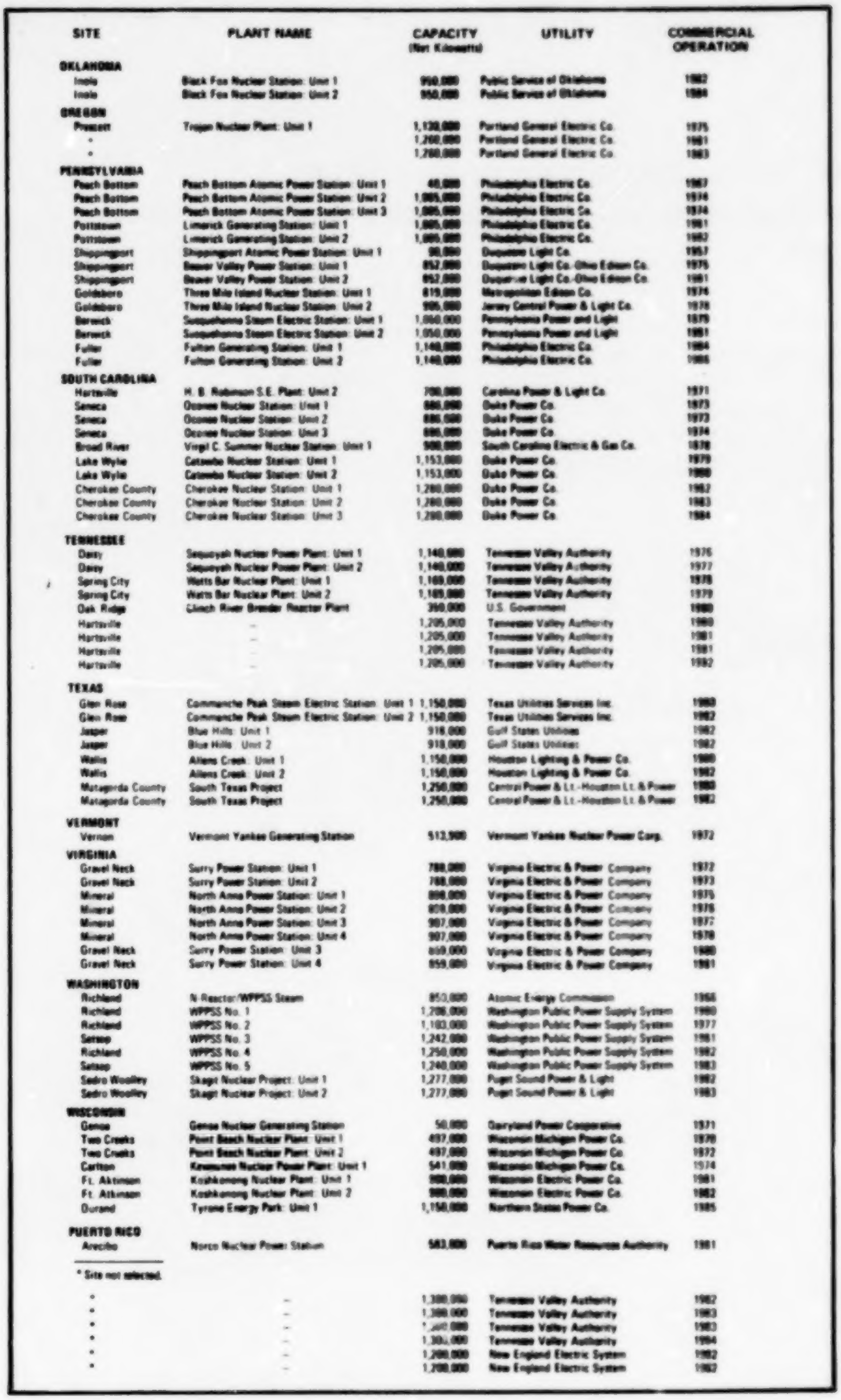
SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Douglas Point	Douglas Point Project Nuclear Gen. Station: Unit 1	1,178,000	Potomac Electric Power Co.	1982
Douglas Point	Douglas Point Project Nuclear Gen. Station: Unit 2	1,178,000	Potomac Electric Power Co.	1984
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
Montague	–	1,150,000	Northeast Utilities	1981
Montague	–	1,150,000	Northeast Utilities	1983
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	75,000	Consumers Power Co	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,093,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,171,000	Detroit Edison Co.	1981
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1976
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,200,000	Detroit Edison Co.	1982
St. Clair County	Greenwood: Unit 3	1,200,000	Detroit Edison Co.	1983
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSOURI				
Fulton	Callaway Plant: Unit 1	1,150,000	Union Electric Co r Co.	1981
Fulton	Callaway Plant: Unit 2	1,150,000	Union Electric Co r Co.	1983
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,250,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,250,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Fort Calhoun	Ft. Calhoun Station: Unit 2	1,150,000	Omaha Public Power District	1983
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1980
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1976
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1979
Salem	Hope Creek Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Salem	Hope Creek Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1983
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1985
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1987
*	–	1,150,000	Public Service Electric and Gas, N.J.	1990
*	–	1,150,000	Public Service Electric and Gas, N.J.	1992
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	490,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
*	Green County Nuclear Power Plant	1,160,000	Power Authority of State of N.Y.	1982
Jamesport	Jamesport 1	1,150,000	Long Island Lighting Co.	1981
Jamesport	Jamesport 2	1,150,000	Long Island Lighting Co.	1983
Oswego	Sterling Nuclear: Unit 1	1,150,000	Rochester Gas & Electric Co.	1982
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1977
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	900,000	Carolina Power & Light Co.	1981
Bonsal	Shearon Harris Plant: Unit 2	900,000	Carolina Power & Light Co.	1982
Bonsal	Shearon Harris Plant: Unit 3	900,000	Carolina Power & Light Co.	1983
Bonsal	Shearon Harris Plant: Unit 4	900,000	Carolina Power & Light Co.	1984
Davie County	Perkins Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1981
Davie County	Perkins Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1982
Davie County	Perkins Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1984
*	–	1,150,000	Carolina Power & Light Co.	1980s
*	–	1,150,000	Carolina Power & Light Co.	1980s
*	–	1,150,000	Carolina Power & Light Co.	1980s
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 1	906,000	Toledo Edison-Cleveland El. Illum. Co.	1976
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 2	906,000	Toledo Edison-Cleveland El. Illum. Co.	1982
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 3	906,000	Toledo Edison-Cleveland El. Illum. Co.	1984
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1979
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	1,170,000	Cincinnati Gas & Electric Co.	1979

Figure 1. Nuclear power reactors in the United States, September 30, 1974—continued



SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OKLAHOMA				
Inola	Black Fox Nuclear Station: Unit 1	950,000	Public Service of Oklahoma	1982
Inola	Black Fox Nuclear Station: Unit 2	950,000	Public Service of Oklahoma	1984
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
*		1,260,000	Portland General Electric Co.	1981
*		1,260,000	Portland General Electric Co.	1983
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1974
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1981
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1982
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1975
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1981
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1978
Berwick	Susquehanna Steam Electric Station: Unit 1	1,050,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,050,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1984
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1986
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,153,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,153,000	Duke Power Co.	1980
Cherokee County	Cherokee Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1982
Cherokee County	Cherokee Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1983
Cherokee County	Cherokee Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1984
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1976
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1979
Oak Ridge	Clinch River Breeder Reactor Plant	350,000	U.S. Government	1980
Hartsville	–	1,205,000	Tennessee Valley Authority	1980
Hartsville	–	1,205,000	Tennessee Valley Authority	1981
Hartsville	–	1,205,000	Tennessee Valley Authority	1981
Hartsville	–	1,205,000	Tennessee Valley Authority	1982
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1982
Jasper	Blue Hills: Unit 2	918,000	Gulf States Utilities	1982
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Matagorda County	South Texas Project	1,250,000	Central Power & Lt.-Houston Lt. & Power	1980
Matagorda County	South Texas Project	1,250,000	Central Power & Lt.-Houston Lt. & Power	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Company	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Company	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Company	1975
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Company	1976
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Company	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Company	1978
Gravel Neck	Surry Power Station: Unit 3	859,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	859,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	850,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,200,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Satsop	WPPSS No. 3	1,242,000	Washington Public Power Supply System	1981
Richland	WPPSS No. 4	1,250,000	Washington Public Power Supply System	1982
Satsop	WPPSS No. 5	1,240,000	Washington Public Power Supply System	1983
Sedro Woolley	Skagit Nuclear Project: Unit 1	1,277,000	Puget Sound Power & Light	1982
Sedro Woolley	Skagit Nuclear Project: Unit 2	1,277,000	Puget Sound Power & Light	1983
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1974
Ft. Atkinson	Koshkonong Nuclear Plant: Unit 1	900,000	Wisconsin Electric Power Co.	1981
Ft. Atkinson	Koshkonong Nuclear Plant: Unit 2	900,000	Wisconsin Electric Power Co.	1982
Durand	Tyrone Energy Park: Unit 1	1,150,000	Northern States Power Co.	1985
PUERTO RICO				
Arecibo	Norco Nuclear Power Station	583,000	Puerto Rico Water Resources Authority	1981

* Site not selected.

*	–	1,300,000	Tennessee Valley Authority	1982
*	–	1,300,000	Tennessee Valley Authority	1983
*	–	1,300,000	Tennessee Valley Authority	1983
*	–	1,300,000	Tennessee Valley Authority	1984
*	–	1,200,000	New England Electric System	1982
*	–	1,200,000	New England Electric System	1982

Figure 1. Nuclear power reactors in the United States, September 30, 1974—continued

Reported Nuclear Detonations, October 1974

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals from a Soviet underground nuclear test were recorded by the United States. The signals originated at approximately midnight e.s.t., November 2, 1974, at the southern Novaya Zemlya nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 3 to 4 megatons.

No nuclear detonations were conducted by the United States for November 1974.

> Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

Erratum

An error occurred in the units for the tritium concentrations in table 3 on page 345 of the June 1974 issue of *Radiation Data and Reports*. The concentrations in this table are in units of *n*Ci/liter instead of pCi/liter.

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  - Radiological surveillance around Turkey Point, 1970–1971, *Mar:105*

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- Uranium
  - Analysis of radiation exposures on or near uranium mill tailings piles, *July:411*
  - ERAMS plutonium and uranium in air component
    - July–September 1973, *Sept:601*
    - October–December 1973, *Oct:680*
    - January–March 1974, *Nov:719*
- Vertebrae
  - Strontium-90 in human vertebrae, *HASL*, 1972, *Oct:683*

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- Washington
  - Radioactivity in Washington surface water July 1971–June 1972, *Oct:668*
- Washington, D.C.
  - Calculated field intensities near a high power UHF broadcast installation, *July:401*
  - HF spectral activity in the Washington, D.C. area, *Sept:549*
- Wastes
  - A summary of low level radioactive wastes buried at commercial sites between 1962–1973, with projections to the year 2000, *Dec:759*
  - Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1973, *Oct:625*
- Water—*see also* Atomic Energy Commission installations; wastes
  - ERAMS surface and drinking water components (formerly the tritium surveillance system)
    - July–September 1973, *May:264*
    - October–December 1973, *June:338*
    - January–March 1974, *Aug:502*
  - Interstate carrier drinking water analysis program, 1972, *Dec:784*
  - Radioactivity in Brazilian mineral waters, *Aug:483*
  - Radioactivity in Florida waters, 1970, *Apr:192*
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  - Radioactivity in Minnesota municipal water supplies, July 1971–June 1972, *Mar:130*
  - Radioactivity in New York State surface water
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    - Erratum, *Dec:856*
  - Radioactivity in North Carolina surface, cistern, and saline waters, 1971, *July:438*
  - Radioactivity in Washington surface water, July 1971–June 1972, *Oct:668*
  - Water surveillance network, *NERC-LV*
    - September 1973, *Jan:14*
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    - First quarter 1974, *June:334*
    - Second quarter 1974, *Sept:588*
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- X ray
  - An evaluation procedure for a nuclear medical department, *Sept:559*

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SYNOPSES

Symposes of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A SUMMARY OF LOW-LEVEL RADIOACTIVE WASTES BURIED AT COMMERCIAL SITES BETWEEN 1962–1973, WITH PROJECTIONS TO THE YEAR 2000. *M. F. O'Connell and W. F. Holcomb.* Radiation Data and Reports, Vol. 15, December 1974, pp. 759–767.

The U.S. Environmental Protection Agency contracted with the six States, having commercial burial facilities for low-level radioactive wastes, to obtain inventories of the types and quantities of wastes buried at these six sites. A compilation and interpretation of the inventory data is presented in tables and figures. Projections are made to the year 2000 of the quantity of low-level radioactive wastes that will result from the nuclear fuel cycle and nonfuel cycle sources. In addition, assumptions are made relating these projections to the available capacity and operational life of the commercial sites. Based on estimates of waste generation rates, it is indicated, assuming present operational practices, that by the year 1998, the six existing sites will exhaust their current burial capacity.

Keywords: commercial burial facilities, Illinois, Kentucky, Nevada, New York, nuclear fuel cycle, South Carolina, radioactive wastes, waste generation rates, Washington